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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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VOL. CXII.—No. 2913.] *LONDON: FRIDAY, OCTOBER 28, 1921.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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John H. Wilson & Co., Ltd., Birkenhead.

See Illustrated Advertisement Page 100, Jan. 28.

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Iron and Steel **Tubes and Fittings.** Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 8746 **The Scottish Tube Co., Ltd,** HEAD OFFICE: 34, Robertson Street, Glasgow. See Advertisement page 85.

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Patent **See's** Hydro-Pneumatic **Ash Ejector.** Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs, Billiter St., London, E.C. Od 4835

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Head, Wrightson & Co., LIMITED. See Advertisement page 71, Oct. 21. 3402

Taylor & Challen Presses 8195 About 200 NEW PRESSES in Stock in our Showrooms for immediate delivery at specially Reduced Prices. TAYLOR & CHALLEN, LTD., Engineers, Constitution Hill, BIRMINGHAM. See Full Page Advertisement page 68, Oct. 14.

Matthew Paul & Co., Ltd. LEVENFORD WORKS, **Dumbarton.** 9318 See Full Page Advt., page 70, Oct. 14.

WAYGOOD-OTIS LIFTS. 9453 54 & 55, FETTER LANE, LONDON, E.C. 4. 62 & 63, LIONEL STREET, BIRMINGHAM. and Principal Provincial Cities.

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£10 Premium will be Paid for any Suggestions leading to SALE of BULK STOCK of 3¾ in. TIMKEN ROLLER BEARINGS. These were made for back axles of heavy trailers and there is no outlet to-day for such large size. Equally suitable for vertical or horizontal shaft. Should preferably be used in pairs.—J. N. FORRESTER, 37, Manchester Road, Denton, Lancs. 9753

See Advt. page 96, Oct. 21 **Steam & Pneumatic Power Hammers Drop Stamping Plant**

B. & S. Massey, Ltd., 9140 MANCHESTER.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

Chief Engineer: C. E. Stromeyer, M.I.C.E. Founded 1854 by Sir William Fairbairn.

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EXCAVATING AND MINING MACHINERY MAKERS

of South Milwaukee, Wisconsin, U.S.A., and formerly represented in the British Isles by Messrs. G. F. West & Co., wish to announce that they have now Opened their Own Office at

19, IDDESLEIGH HOUSE, CAXTON STREET, WESTMINSTER,

and henceforth All Communications for them should be so addressed.

9741

The Institution of Mechanical Engineers.

THOMAS HAWKSLEY LECTURE, 1921.

Dr. H. S. Hele-Shaw, F.R.S., Vice-President, will deliver the above Lecture on "Power Transmission by Oil," at the Institution, Storey's Gate, Westminster, on FRIDAY, 4th NOVEMBER, 1921, at Six p.m.

Visitors are Invited. S 400

Battersea Polytechnic

London, S.W. 11.

A COURSE OF about 24 LECTURES with Laboratory Work on—

"THE TECHNOLOGY OF FUELS"

is being given by

Mr. A. R. Pearson, M.Sc.,

on

Friday Evenings from 7 to 9.30.

The Course began on October 14th. Fee 2/-

S 390

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B.Sc., Inst. C.E., I. Mech. E., all ENGINEERING EXAMS. Special Courses and Single Subjects. Personal tuition.—For full particulars apply to Mr. TREVOR W. PHILLIPS, B.Sc. (Hons.), Assoc.M.Inst.C.E., M.R.S.I., etc., 8-10, Trafford Chambers, 58, South John Street, Liverpool. 9296

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as usual last Exam. by Correspondence Coaching. Successes by hundreds, several prizes. Sec. "O" embraces 25 years' professional experience. Address, 7434, Offices of Engineering.

TENDERS.

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following STORES, namely:

No.		Specification Fees.
1.	Points and Crossings, &c.	10s. 0d.
2.	Tiebars, Gibs and Cotters	10s. 0d.
3.	Steel Fishbolts and Washers	7s. 6d.
4.	Fencing Materials	10s. 0d.
5.	Fencing Wire Strand	10s. 0d.
6.	Galvanised Wrought Iron Water Tubes, &c.	7s. 6d.
7.	Rail Lifters, &c.	5s. 0d.
8.	Water Cranes	7s. 6d.
9.	Acid Open Hearth Steel Boiler Plates	7s. 6d.
10.	Galvanised Corrugated Sheets	10s. 0d.
11.	Metals, &c.	10s. 0d.
12.	Leather, Belting, &c.	£1 0s. 0d.
13.	Wood Handles	7s. 6d.
14.	Platelayers' Tools	10s. 0d.
15.	Paints, Drysalteries, &c.	£1 0s. 0d.
16	Malleable Cast Iron Brackets	2s. 6d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Points and Crossings, &c.," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 8th November, 1921.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 26th October, 1921. S 437

CITY OF LEICESTER. WATERWORKS DEPARTMENT. CAST-IRON PIPES.

The Water Committee of the City of Leicester invite

Tenders for the Supply and

DELIVERY of about 2,700 tons of 27 in. diameter CAST-IRON PIPES.

Conditions of Contract, Specification and Form of Tender may be obtained by Foundry Companies or their Agents from the Undersigned.

Sealed Tenders upon the form supplied endorsed "27 in. diameter Cast-Iron Pipes," are to be delivered to the undersigned on or before the 14th November next.

The Committee do not bind themselves to accept the lowest or any Tender.

G. T. EDWARDS, M.Inst.C.E.,
Water Engineer and Manager.

Waterworks Office,
Bowling Green Street, Leicester.
October 13th, 1921. S 339

BOROUGH OF AYLESBURY.

ELECTRIC MOTORS AND PUMPS.

Tenders are Invited for

SUPPLYING and FIXING complete—

CONTRACT No 1.

TWO VERTICAL A.C. ELECTRIC MOTORS and FIVE HORIZONTAL A.C. ELECTRIC MOTORS, &c.

CONTRACT No. 2.

TWO VERTICAL CENTRIFUGAL PUMPS and THREE HORIZONTAL CENTRIFUGAL PUMPS, Delivery Pipes, Valves, &c., at the Sewage Works, Bicester Road, Aylesbury. (NOTE.—In the event of a Contractor quoting for both Contracts he must send separate Tenders in for each Contract.)

Plans and Specification may be seen on application to the undersigned upon payment of £1 1s., which will be returned on receipt of a *bona fide* Tender and return of all documents.

Sealed Tenders, endorsed "Tender for Electric Motors and Pumps," together with Drawings, to be delivered to my Office not later than Twelve o'clock noon on Friday, November 11th, 1921.

Contractors desirous of being shown over the site are requested to make arrangements with Engineer and Surveyor.

The Council does not bind itself to accept the lowest or any Tender.

WM. HAROLD TAYLOR,
Borough Engineer and Surveyor.

Town Hall,
Aylesbury.
October 21st, 1921. S 361

LLANDAFF AND DINAS POWIS RURAL DISTRICT COUNCIL.

RHOOSE VILLAGE DRAINAGE.

TO CONTRACTORS.

The Council invite

Tenders for the Construction

of Certain Lengths of STONEWARE and IRON SEWERS of 9 inches in diameter, together with the necessary Manholes, Flushing Tanks and other Appurtenances.

The Contract also includes the Construction of a Sea Outfall, formed of 9 inch Cast-iron Pipes, laid through the rock foreshore in accordance with plans and specification prepared by Mr. G. Midgley Taylor, Civil Engineer.

Contractors desirous of tendering may obtain copies of the Specification, Bill of Quantities and Form of Tender, from the Offices of the Engineer, 36, Victoria Street, Westminster, S.W. 1, upon payment of £5 (cheque only), which will be returned upon receipt of a *bona fide* Tender. The drawings may be inspected either at the Offices of the Engineer, Westminster, or at the Office of the Surveyor to the Council, Mr. William Farrow, Park House, Cardiff.

Tenders endorsed "Rhoose Drainage," must be delivered in a sealed package addressed to the undersigned at his Offices, Cardiff, before Ten a.m. on Wednesday, the 16th day of November, 1921.

The Council do not bind themselves to accept the lowest or any Tender.

By Order,
M. WARREN,
Clerk to the Council.

Council Offices,
Park House,
20, Park Place,
Cardiff.
20th October, 1921. S 387

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply

of—

(A) 25 BOGIE CARRIAGE UNDERFRAMES (without Wheels and Axles) Comprising 7 1st and 2nd class Composite Bogie Carriages.
3 3rd Class (Women's) Bogie Carriages.
15 3rd Class Bogie Carriages.

(B) 200 WHEELS (without axles) for above Carriages.

(C) 94,000 STEEL FISHBOLTS for 60 lbs. (B.S.) Rails.

(D) 705,800 DOG SPIKES for 60 lbs. (B.S.) Rails. Sufficient for 72 miles of track.

Fees, which are not returnable, will be charged for these specifications as follows:—

For each copy of Specification (a), 20s.
For each copy of Specification (b), 5s.
For each copy of Specification (c), 10s.
For each copy of Specification (d), 10s.

Tenders enclosed in sealed envelopes addressed to the "Chairman and Directors" and endorsed "Tender for Carriage Underframes" or as the case may be, must be delivered at the Company's Offices not later than Twelve noon on the following dates:—

Carriage Underframes and Wheels. } Friday, 11th November, 1921.

Steel Fishbolts and Dogspikes. } Friday, 4th November, 1921.

The Directors do not bind themselves to accept any or the lowest tender and reserve the right to divide the orders.

The Fishbolts and Dogspikes are urgently required in Burma.

By Order of the Board,
F. C. FRANKS,
Secretary.

190, Gresham House,
Old Broad Street,
London, E.C. 2.
26th October, 1921. S 426

THE MINISTRY OF PUBLIC WORKS, EGYPTIAN GOVERNMENT,

are calling for

Tenders for the Supply of

PUMPING PLANT and MACHINERY to be erected by the Contractors at Atf.

The Plant to include four Diesel or Semi-Diesel Engines, each directly coupled to a Turbine or Centrifugal Pump, with all necessary pipes, etc.

Conditions of Tender and Specification, price 10s., can be obtained from:—

THE INSPECTING ENGINEER, S 297
Egyptian and Sudan Governments,
Queen Anne's Chambers,
Westminster, S.W. 1.

METROPOLITAN WATER BOARD.

SUPPLY OF 42 in. AND 48 in. STEEL TUBES.

The Metropolitan Water Board invite

Tenders for the Supply

of:—

(A) Approximately 155 ft. of 42 in. LAPWELDED STEEL TUBE (the final riveting of field joints to be done "in situ") for the crossing of River Lee at Lea Bridge.

(B) Ten 16 ft. and Four 8 ft. lengths of 48-in. LAPWELDED STEEL TUBES for the Walton to Honor Oak Main.

Forms of Tender, Conditions of Contract, etc., may be obtained on personal application at the Offices of the Board (Room 159), New River Head, 173, Rosebery Avenue, E.C.1, or will be forwarded on receipt of a stamped addressed envelope.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1," and endorsed "Tender for Steel Tubes," must be delivered at the Offices of the Board not later than Eleven a.m on 11th November, 1921.

The Board do not bind themselves to accept the lowest or any Tender.

W. MOON,
Clerk of the Board.

New River Head,
173, Rosebery Avenue, E.C. 1,
21st October, 1921. S 403

METROPOLITAN WATER BOARD.

SUPPLY OF 48 in. CAST IRON PIPES, &c.

The Metropolitan Water Board invite

Tenders for the Supply of

approximately 9,600 tons of CAST-IRON PIPES and SPECIAL IRREGULAR CASTINGS (British Standard Specification) required in connection with the Walton to Honor Oak Main Section No. 2 (Malden to Clapham Park).

Forms of Tender, and Conditions of Contract, etc., may be obtained on personal application at the Offices of the Board (Room 159), New River Head, 173, Rosebery Avenue, E.C. 1, or will be forwarded on receipt of a stamped addressed envelope.

Tenders, enclosed in sealed envelopes addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C. 1," and endorsed "Tender for 48 in. Cast Iron Pipes," must be delivered at the Offices of the Board not later than Eleven a.m. on 11th November, 1921.

The Board do not bind themselves to accept the lowest or any Tender.

W. MOON,
Clerk of the Board.

New River Head,
173, Rosebery Avenue, E.C. 1,
21st October, 1921. S 402

MIDLAND GREAT WESTERN RAILWAY OF IRELAND.

CONTRACTS FOR 1922.

The Directors of the Midland Great Western Railway of Ireland Company are prepared to receive

Tenders for the Supply of the

undermentioned STORES. The Contracts to commence from the 1st of January next, and to be for three or six months.

	No. of Form.		No. of Form.
Asbestos & Packing	1	Locks, Rainwater Goods & Hardware	25
Barrows and Trucks	2	Oils	26
Baskets and Mats	3	Paints, Colours and Wallpaper	27
Brushes, Brooms, &c.	4	Ropes and Canvas	28
Brass Fittings for Gas and Water	5	Rail Fastenings, iron	29
Bolts, Nuts and Rivets	6	" " steel	30
Bricks, Slates, Earthenware Pipe, &c.	7	Screws, Split Pins, Nails, &c.	31
Chain	8	Sheet Tin, Lead, Gun Barrel, &c.	32
Cement	9	Steel Tyres, Axles and Plates	33
Candles and Soap	10	Steel & Copper Tubes, Copper Plates and Ingots	34
Carriage Fittings do. Trimmings	11 12	Steel Castings	35
Clothing	2A	Staffordshire Iron, Wire, &c.	36
Creosote Oil	13	Springs, Steel, and Pins	37
Drysalteries	14	Soft Goods	38
Fog Signals	15	Timber, &c.	39
Farm Produce Boxes	16A	Tools	40
Glass	17	Tool & Barrow Shafts	41
Grease	17	Varnishes	42
Gas Mantles, &c.	18	Wagon Covers and Tarpaulins	43
Iron & Steel Forgings	19	Waste and Wicking	44
Iron Castings	20	Yorkshire Iron	45
India Rubber Goods	21		
Lime	22		
Leather and Belting	23		
Lamps and Tinware	24		

Forms of Tender can be obtained, on payment of 6d. each, from the STOREKEEPER, GENERAL STORES DEPARTMENT, BROADSTONE STATION, DUBLIN. *Please do not send Stamps.*

Patterns and Samples can be inspected at the same place on and after 1st prox., between the hours of Ten a.m. and Four p.m. (Saturdays, Ten a.m. to Twelve noon).

Contractors cannot be allowed to tender to supply goods to their own patterns, nor can the Company's patterns be sent away for inspection.

The Directors will not consider any Tender unless furnished on the Company's forms; nor any Tender in which any alteration of the form has been made.

The Tenders to be sent in by post, sealed and endorsed on the envelope, "Tender for Stores, Form No. ——," and addressed to "The Chairman, Broadstone Station, Dublin," so as to reach him on or before Ten a.m. on the 15th November.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order,
PERCY A. HAY,
Secretary.

Broadstone Station, Dublin,
October, 1921. S 431

BRISTOL WATERWORKS. CHEDDAR SUPPLY.

The Directors of the Bristol Waterworks Company invite

Tenders for the Construction

of an INTAKE CHAMBER, RIVER WEIR, GAUGE BASIN and other Works at Cheddar.

Contractors desirous of tendering may obtain a copy of the General Conditions, Specification, Bill of Quantities and Form of Tender, and may inspect the Drawings at the Office of the Company's Engineer, Telephone Avenue, Bristol, or at the offices of Messrs. John Taylor & Sons, Civil Engineers, 36, Victoria Street, Westminster, S.W. 1, upon payment of £5 (Cheque only) which will be returned on receipt of a *bona fide* Tender.

Tenders, endorsed "Bristol Water, Cheddar Intake Works," must be delivered in a sealed package addressed to Messrs. John Taylor & Sons, Civil Engineers, 36, Victoria Street, Westminster, S.W.1, before Ten a.m., on Tuesday the 8th November, 1921.

The Company does not bind itself to accept the lowest or any Tender.

(Signed) W. A. D. ALEXANDER,
Secretary.

Bristol, October, 1921. S 420

TREDEGAR URBAN DISTRICT COUNCIL

WATERWORKS. CONTRACT No. 3.

TO CONTRACTORS.

The Council are prepared to receive

Tenders for the Raising and

WIDENING of the EMBANKMENT of the Shon Sheffrey's Reservoir and the extension of the ends thereof, the raising of the outlet well, extension of outlet tunnel, the construction of stone drains, weir, overflow channel, stone pitching and pathways, also the diversion of a line of sewer and manholes in accordance with Drawings and Specification prepared by Messrs. John Taylor and Sons, Civil Engineers.

Copies of the Specification, Bill of Quantities, and Form of Tender may be obtained from the Offices of the Engineers, 36, Victoria Street, Westminster, S.W. 1, upon payment of £5 (cheque only), which will be returned upon receipt of a *bona fide* Tender. The Drawings may be inspected either at the Offices of the Engineers, or at the Office of the Council's Water Manager, Mr. D. Walter Davies, at Tredegar.

Sealed Tenders endorsed "Tredegar Water, Contract No. 3," addressed to the Clerk to the Council, Bedwellty House, Tredegar, are to be delivered at his Office at or before Ten a.m., on Tuesday, the 22nd day of November, 1921.

The Council do not bind themselves to accept the lowest or any Tender.

H. J. C. SHEPARD,
Clerk.

Bedwellty House,
Tredegar, Mon.
24th October, 1921. S 417

APPOINTMENTS OPEN.

TECHNICAL COLLEGE, BRADFORD.

Applications are Invited for

APPOINTMENT as HEAD of the DEPARTMENT of CIVIL ENGINEERING in the College.

A salary up to £700 per annum will be paid to a candidate of suitable qualifications and experience.

Full particulars of the appointment and forms of application may be obtained from the Principal of the College.

Applications to be returned so as to reach me as soon as possible.

N. L. FLEMING,
Town Clerk.

20th October, 1921. S 395

Works Superintendent

REQUIRED by manufacturers of Electric Accumulators, Midland counties. Must have good mechanical engineering experience and be accustomed to handle men. Knowledge of accumulator construction not essential.—Address, S 283, Offices of Engineering.

ASSISTANT LOCOMOTIVE SUPERINTENDENTS, INDIAN STATE RAILWAYS.

THE SECRETARY OF STATE FOR INDIA, will, in 1921, with the advice of a Selection Committee, make

Three Appointments of

ASSISTANT LOCOMOTIVE SUPERINTENDENTS for service on Indian State Railways, if so many suitable candidates present themselves.

Candidates must be British subjects not more than 27 years of age, and must be of good moral character and sound physique.

They must have had a good general and technical education, followed by at least three years' training in the locomotive workshops of a British Railway Company, or a locomotive builder of repute, and should have had six months' training in the running sheds and firing. A knowledge of applied mechanics and the nature and composition of all materials used in shops is essential, and applicants should be able to design and to calculate the stresses on the parts of the machines. Some drawing office experience is also desirable.

Persons whose practical experience falls short of three years, but who have served in His Majesty's Forces during the war will be eligible as candidates; but, if selected, will be required before appointment to complete satisfactorily such further period of training as the Secretary of State may prescribe.

Candidates may be required to appear before a Selection Committee at the India Office. They will also be required to pass a medical examination if selected for appointment.

The Regulations in respect of the appointments and Forms of Application for use by candidates can be obtained on application to the Secretary, Public Works Department, India Office, Whitehall, London, S.W.1. Applications for appointment must reach the India Office not later than 15th November, 1921.

India Office,
22nd September, 1921. S 162

Supervising Erecting Engineer

WANTED, for Firm in the North. Applicants must have had experience in the erecting, wiring, and running of large Rolling Mills and other classes of electrical apparatus.—Address, with particulars of training, age, experience, and salary required, S 307, Offices of Engineering.

THE NEW WINNIPEG WATERWORKS.

By Frank W. Skinner, M.Am.Soc.C.E.

The City of Winnipeg, Canada, not yet fifty years old, is a great agricultural and commercial centre located on the lines of the Canadian Pacific, Grand-Trunk Pacific, Northern Pacific and Canadian Northern Railroads, at the junction of the Red River and the Assiniboine River, in the province of Manitoba. From a population of 1,869 in 1874, it has grown to one of about 250,000.

Until 1880, when the population was less than 20,000, the water supply was from wells, distributed in barrels hauled on carts in summer and on sleds in winter. In about 1882 a pumping plant was installed on the Assiniboine River, and the water was filtered and distributed through street mains until 1905, when a new supply of ground water superseded the river water supply. As the water was very hard and was unfavourable for the use of manufacturing or industrial works and was unsatisfactory for domestic purposes, increasing efforts were made, at intervals for several years, to secure a better supply of pure soft water and several investigations, reports and recommendations were made by expert engineers.

In 1907, James H. Fuertes, of New York, was appointed one of a Commission that, after investigating several proposed sources, recommended that the supply be taken from the Lake of the Wood, or Shoal Lake. This report, after being endorsed by two other Commissions, was adopted by the officials of the Greater Winnipeg Water District, in 1913, and Mr. Fuertes was made consulting engineer and designed the structures with general direction of the construction of the work.

Notwithstanding the fact that the general designs and estimates were made and the work commenced one year before the beginning of the great world war, when there was abundance of men, materials, and transportation at moderate prices, and that conditions changed rapidly to an unprecedented scarcity of essentials and unexampled high prices, this work was successfully completed and put in operation in four years and five months, at a cost of only about 15,000,000 dols.; practically within the originally estimated cost, and providing a capacity more than 17 per cent. in excess of that required by the specification.

None of the features of the installation were experimental, but the latest practice, thoroughly studied, modified and combined with the skill gained from long and successful experience in important hydraulic engineering construction, the ultimate aim being to secure the best final and permanent results with the greatest rapidity, safety and smallest total expense. One of the most notable features of the work was the good judgment displayed when a departure from tradition, by balancing the economies of special construction plus possible repairs, gave more rapid and economical results than massive construction that would not have secured any better or safer service, and would have cost considerably more. It was realised that the conservative copying, under new conditions, of structures designed to suit other circumstances does not suffice for the best results.

Careful consideration was given to all the elements of location, construction, maintenance, operation, safety, durability, capitalisation and amortisation, and decisions were made to assure the results best suited as a whole to the advantage of the owners. Some risks were taken and others were avoided, and the advantages were made to balance the disadvantages. For these good and sufficient reasons it was decided to make the aqueduct of comparatively light construction, and many miles of it were built with thin walls, arch, and invert, that effected an important saving over the heavier construction that would have been necessary with less careful investigation and design.

Much of the aqueduct is in swamps, supported on soft soil, where great precautions were taken to prevent settlement that would inevitably have caused extensive and dangerous cracking. The investigations and experiments included many tests of full-size inverts of reinforced concrete with different dimensions that eventually determined the dimensions of no less than 16 different inverts that were used at various places and under different conditions.

Some of the auxiliary structures were designed on original lines, and provided for unusual requirements, such as protection of the invert from frost in the very cold climate and the proportioning of the arch and side walls of the horseshoe-shape conduit to resist the unusual action of frost which at a depth of 4 ft. from the surface of the backfill was sufficient to expand the frozen crust and lift it entirely clear of the extrados of the arch, leaving a lune-shape void over the haunches, between the concrete and the frozen plane. This occurred at points where the covering was ample to protect the water in the aqueduct from freezing and to maintain it at a temperature which varied only about 1 deg. from the summer or winter temperature in the supply lake.

A saving of about 1,000,000 dols. was made, by increasing the total length of the aqueduct about 8 per cent. more than that of the straight line location and thus permitting the flattening of the hydraulic grade line at the junction of the flat and steep grades so as to reduce the maximum depth of cuts 1 ft. for a 9-mile rock cut, 22 ft. deep. These features and the special design of important auxiliary construction were important for securing increased efficiency, rigidity and economy.

Supply.—The water is derived from Indian Bay, about 6 miles long and from 1 mile to 3 miles wide, which is an arm of Shoal Lake. This lake has a water area of 110 sq. miles and a watershed of 360 sq. miles and is connected by a narrow natural channel with the Lake of the Woods which supplements it with an almost unlimited supply. Originally the water in Indian Bay was highly coloured by swamp drainage through the Falcon River, which discharges into the bay, a condition that was removed by building a dike in the shallow water across the end of Indian Bay intercepting the Falcon River flow and diverting it through a canal to Snowshoe Bay. The cost of this work was about 147,000 dols.

The dike was completed in 1914 and the success attained was shown by the fact that on June 7, 1918, the colour of the water of the Falcon River side of the dike was 107, while the colour on Indian Bay side of the dike on the same day was 9. The colour in the bay changes according to the season and the character of the water and the amount of floating substances are affected by the semi-annual turnover of the water in the bay. In the fall the steadily falling temperature causes the water to get colder and colder on the surface and therefore drop to the bottom, causing the bottom water to rise, and in the Spring the ice goes out and the temperature of the water gradually rises and, at 38 deg., sinks from the surface to the bottom, displacing the lower stratum which, as it comes up, brings with it large quantities of grasses and weeds.

Design and Location.—As the low-water elevation of Indian Bay is 1,057·6 and the high-water elevation is 1,065, while the elevation above sea-level of the flow line of the Winnipeg reservoir is 770, there was available a minimum total head of 295 ft. for the gravity operation of the aqueduct 99 miles long. With the exception of three critical points, one near Snake Lake, another at the crossing of the Brokenhead River, and a third where the aqueduct passes through the only available low ground between the Brokenhead River Valley and the English River Basin, the country is so flat that the aqueduct could have been run on almost any alignment, and the location was determined largely by foundation considerations, the soil being generally soft and swampy and in many places unable to bear the weight of the aqueduct.

The aqueduct was constructed under an Act of the Dominion Parliament creating the Greater Winnipeg District consisting of the City of Winnipeg and six smaller municipalities having a combined present population of about 265,000, and a consumption, at the time that the Act was passed, of about 15,000,000 gallons of water daily. The Act empowered the taking up to 100,000,000 gallons of water daily from Indian Bay, and required it to be furnished in bulk if demanded, and that the smaller municipalities be included in the district. This provision, and the unknown amount of water that would be used and the uncertain rapidity with which the requirements will be increased, complicated the design and construction of the aqueduct, which was finally built to serve at first, and probably for a number of years, until the demands on it are materially increased, entirely as a gravity conduit. It is provided near the lower end with outlets that may be utilised to supply water to the other municipalities, with devices for measuring the water, and with connections for the future installation of booster pumps, to increase the flow through certain parts of the aqueduct, which are thus now made smaller than the dimensions which would be required for ultimate maximum gravity flow. Provision is also made for the eventual construction of some 20 miles of supplementary conduit and a large equalising reservoir at a distribution point about 15 miles from Winnipeg.

These arrangements enabled the structure to be built at minimum cost for the present service and provided for its 100 per cent. utilisation for increased needs, which may be assisted as required by additional construction which need not be made in advance, thus eliminating a large amount of interest and maintenance charges and providing for more exact design in accordance with unknown later development.

The structure as now built may be divided into 10 general items: (1) Intake of Indian Bay, (2) Venturi meter, 1 mile below intake; (3) gravity flow concrete aqueduct from Indian Bay for a distance of 80·54 miles; (4) an 8-ft. reinforced concrete pressure aqueduct 4·2 miles long; (5) concrete aqueduct, 294·5 ft. long, at site of equalising reservoir, containing a 5-ft. shut-off gate in aqueduct, equalising reservoir intake, Venturi meter and a shut-off gate in the 5-ft. 6-in. line; (6) a 5-ft. reinforced concrete pipe, 49,900 ft. long, delivering a maximum amount of 59,000,000 gallons daily with two 36-in. outlets, a 24-in. outlet and a connection to the surge tank; (7) the Red River surge tank; (8) Red River tunnel containing a 5-ft. diameter cast-iron pipe with connections to the future booster pump of 50,000,000 gallons per day; (9) a 36-in. connection and a 24-in. connection at the lower end of the tunnel for future district supplies; (10) a 48-in. reinforced pipe, 12,000 ft. long, from the Red River tunnel to the Winnipeg reservoir, with two 24-in. outlets for district supplies.

The capacity of this present aqueduct to deliver by gravity alone to the Winnipeg reservoir is 28,500,000 imperial gallons daily. When the requirements equal this amount future increases will be provided by the installation of the booster pump at the surge tank and an additional reservoir will have to be built near Winnipeg to provide for the hourly fluctuations in demand.

In order to regulate the rate of flow in the aqueduct as required by the demand and to prevent the possibility of upward pressure on the roof or arch of the aqueduct in case of accident of any kind, stop plank chambers and overflows, as well as blow-offs, have been installed at all the principal river crossings and at the end of the gravity flow aqueduct, and large gates at the intake. There has also been connected to the aqueduct a stand pipe with an overflow at elevation 785·5 somewhat above that required to give the necessary pressure head for the delivery of the maximum gravity flow to the Winnipeg reservoir. An overflow has also been placed at the Winnipeg end of the gravity section with lips at elevation 797·6 to protect the flow to the gravity section below the 8-ft. diameter circular-pressure section.

The general problem of alignment was to secure a grade averaging as closely as possible to the mean slope between termini with the least deviation from the shortest line, so that the excess length above the straight line could be saved in the reduced amount of concrete, excavation and construction cost secured by the longer alignment and flatter slope. An analysis of these conditions showed that for the 7-ft. by 8-ft. 3¾-in. aqueduct, the line could be lengthened 14 per cent. to avoid a cut 6 ft. greater than the most economical depth of cut.

Although in most cases the surface of the ground was flat and at a favourable elevation, the soil was often so wet and soft as to be unsuitable to bear

the aqueduct, thus requiring either a pile foundation, a deep cushion of gravel, or a very deep trench producing extra pressure and involving the use of reinforcement steel for the concrete. All of these alternatives were costly, and careful studies were made to select the most favourable one. Many miles of the aqueduct were laid on gravel footings, and there were nine depressed sections with pressure heads varying from 7 ft. to 65 ft.

The most important cut, near Indian Bay, was 9 miles long and 25 ft. in maximum depth. The grade for about 7 miles was 0·11 ft. per 1,000 and the grade on the next section was 0·279 ft. per 1,000, with a correspondingly smaller cross section of aqueduct. By continuing the large aqueduct section on the flat grade for a distance of 11,100 ft. down the steeper slope before changing to the smaller cross-section, the discharge through the latter was increased to equal that through the flat slope and permitted the average elevation of the aqueduct through the deep 9-mile cut to be about 10 in. higher than if the large section had ended and the smaller begun at the difference in grades, thus effecting a large saving in the total cost of the construction of this 9 miles of aqueduct. A diagram of the summit cut with water surface elevations for alternative lay-outs is given in Fig. 1, annexed.

The aqueduct through the deep cut was made large enough to deliver, in times of high water in Indian Bay, 120,000,000 gallons per day, thus obviating for many years the necessity of enlargement for this most expensive portion of the work. Had the aqueducts been located on a straight line from Indian Bay to Winnipeg the cost would have been from 2,000,000 dols. to 3,000,000 dols. more than by the present route, because the shorter line would have consisted of long sections of aqueduct with an enlarged cross-section on flat grade connected by short sections of smaller dimensions on steep grade, thus involving a considerably larger amount of material in construction.

Most of the country traversed by the aqueduct is so flat and was so heavily covered with brush and timber, or so wet and boggy, that the alignment could not be made by inspection, and it was necessary to run levels on offsets sometimes 20 miles long, from the preliminary line in order to make a map with contours at 1 ft. or 2 ft. intervals, on which to mark the location. It was also necessary to make many soundings and wash borings in the swampy area to locate the hard subsoil and determine whether to use a foundation fill, depressed section, or pile foundation, and to make comparative estimates of the cost.

The elevation of the aqueduct relative to the original surface of the ground was an important element of the cost and was carefully balanced against the grade line. Very shallow cuts requiring large embankment to afford sufficient covering to protect the aqueduct from accident or frost, and very deep trenches requiring excessive excavation, were avoided as much as possible because both cost much more per linear foot than the moderate average cut. Comparative estimates of total cuts, including the stripping, excavating, timber platform, concrete and backfilling, indicated that for the local conditions and method of payment, an average cut of some 4 ft. for the smallest to 5·5 ft. for the largest section corresponded to the minimum cost per foot of completed work.

Type of Aqueduct.—For a distance of about 80 miles from the intake the aqueduct is a horseshoe-shape concrete gravity conduit, designed to run not quite full, except where the crest is below the hydraulic grade at a river crossing, and near Winnipeg, where it changes to a circular section reinforced against external as well as internal pressure. The largest section, in the deep cut near the intake, is 10 ft. 9 in. wide and 9 ft. high, on a slope of 0·58 ft. per mile; the smallest gravity section is 6 ft. 4½ in. wide and 5 ft. 4½ in. high on a slope of 1·537 ft. per 1,000, the steepest of the whole line. All of this gravity section of the aqueduct has a discharging capacity of 85,000,000 Imperial gallons daily, which is far in excess of the needs of Winnipeg for many years.

On the end of the gravity section adjacent to Winnipeg, about 17 miles of the aqueduct is under pressure and has a maximum diameter of 8 ft. The aqueduct at present delivers by gravity 28,500,000 gallons daily, a quantity which may be increased by future pumping. This part of the aqueduct includes about 4 miles of the circular section, 8 ft. in diameter, 49,900 ft. of 5-ft. 6-in. lock-joint pipe, a cast-iron inverted syphon 5 ft. in diameter under Red River and 11,400 ft. of lock-joint reinforced concrete pipe 48 in. in diameter extending from the Red River to the Winnipeg reservoir. The pressure head on the 5-ft. 6-in. pipe will vary from 12 ft. to 47 ft. before the installation of the booster pump, and after that may rise to a maximum of 61·5 ft.

All of the gravity section of the conduit built up to April, 1916, had a horseshoe-shape cross-section, invert that demonstrated superiority to the plain, thin, inverts with an extended base, was an invert with a thickness of 11½ in. and a reinforcement of ⅝-in. square bars, 4 in. apart.

As a result of these tests the remainder of the aqueduct was built with inverts of three types designed for use in different kinds of soil. As used for compressible soil the standard invert first designed as shown in Fig. 3, on page 591, was modified by increasing the thickness from 6 in. to 7½ in. to 12½ in. and by reinforcing it with ⅝-in. bars, from 7½ in. to 9 in. apart on centre, according to the size of the aqueduct. This is shown in Fig. 4. The type and dimensions finally adopted for solid foundation was the invert originally designed, which,

Fig. 1. CALCULATED WATER SURFACE ELEVATIONS IN AQUEDUCT AT SUMMIT CUT UNDER DIFFERENT CONDITIONS OF DISCHARGE.

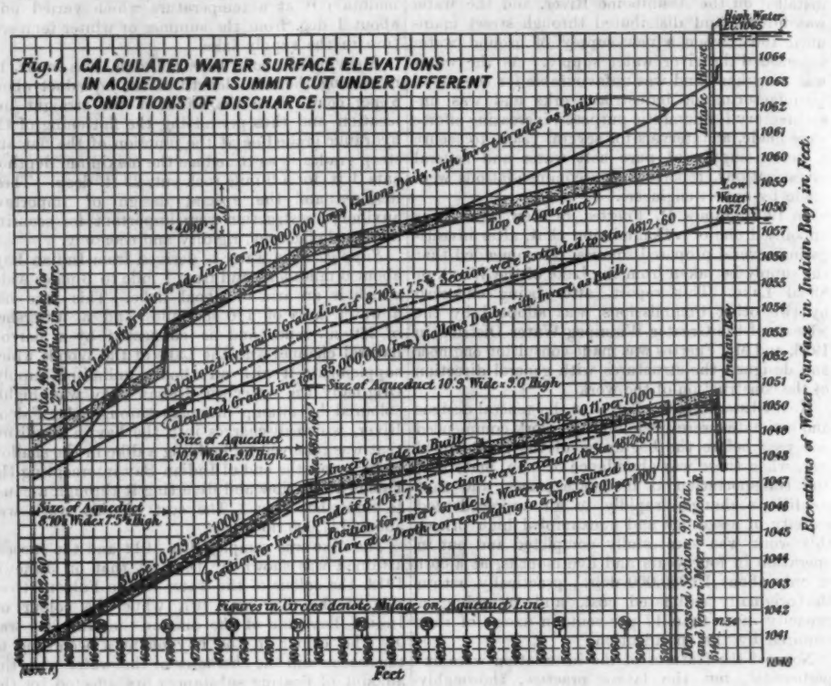
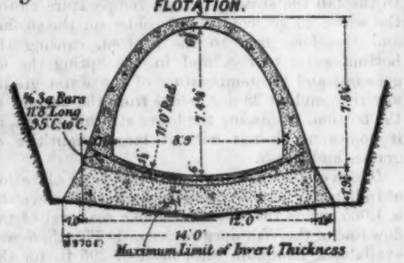

High Water 1067.0 M.S.
Intake House
Low Water 1057.6 M.S.
Indian Bay
Calculated Hydraulic Grade Line for 120,000,000 (Imp.) Gallons Daily, with Invert Grade as Built
Top of Aqueduct
Calculated Hydraulic Grade Line at 8'10½" x 7'5" Section were Extended to Sta. 4812+60
Calculated Grade Line for 85,000,000 (Imp.) Gallons Daily, with Invert as Built
Size of Aqueduct 10'9" Wide x 9'0" High
Slope 0·11 per 1000
Invert Grade as Built
Size of Aqueduct 8'10½" Wide x 7'5" High
Slope 0·279 per 1000
Position for Invert Grade if C.H. 10'5" x 7'5" Section were Extended to Sta. 4812+60
Position for Invert Grade if Water were assumed to Flow as a Depth corresponding to a Slope of 0·11 per 1000
Figures in Circles denote Mileage on Aqueduct Line
Depressed Section, 9'0" Dia. and Venturi Meter at Falcon R.
Feet
Elevations of Water Surface in Indian Bay, in Feet.

Fig. 2. SPECIAL INVERT FOR SECTION B TO RESIST FLOTATION.



with an invert composed of a concrete slab as wide as the complete spread of the arch from out to out, with the upper surface curved to a radius of 14 ft. for the largest size conduit, and 8 ft. 1½ in. for the smallest size. The invert was 6 in. thick in and near the centre, sloping upwards at each side, and was made in 15-ft. lengths with a crimped copper expansion joint between each two adjacent slabs.

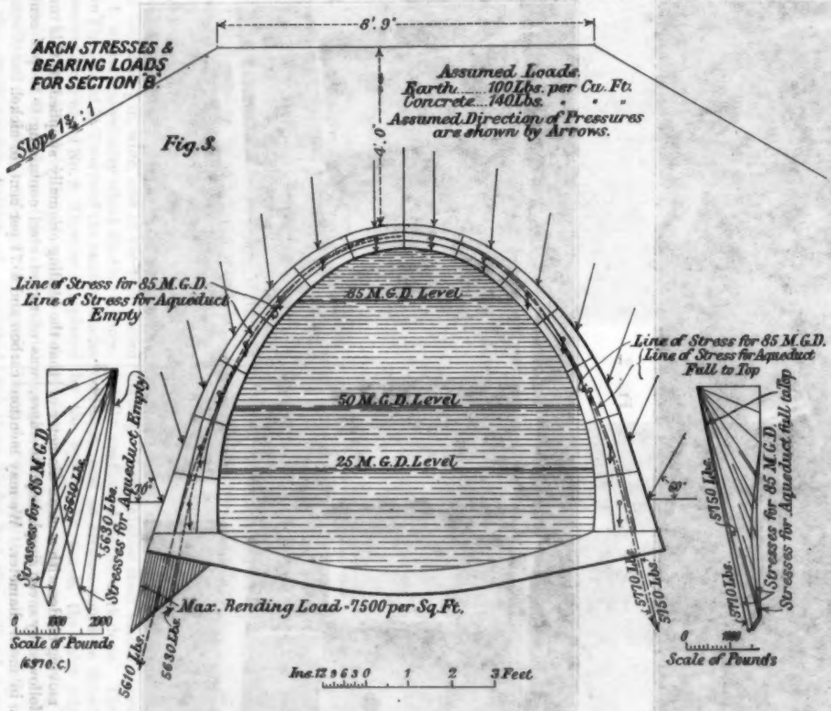
On account of the settlement in soft ground, cracks developed in the invert which led to the investigation of its strength, a modification of its design by a series of actual tests on six full-size inverts of an 8-ft. 9-in. by 10-ft. 4½-in. aqueduct. Each invert was made 2 ft. long and was built on the natural earthy surface, trimmed to shape. All of these inverts were of standard dimensions, built in the regular way, and loaded with 60-lb. rails. Various types of reinforcement were tried, as well as extended bases. The settlements produced at each end, at the middle and at the quarter points, were accurately measured and recorded. The loadings were also recorded at the times that the different cracks developed. The only reinforced for somewhat poorer foundations, was modified by 8 in. extension on each side. For compressible foundations the original invert was thickened to 12½ in. and reinforced with ⅝-in. bars from 7½ in. to 9 in. apart. The use of these expensive inverts eliminated the development of longitudinal cracks, but did not stop the formation of transverse cracks in the arches, which could only have been prevented by building the aqueduct on pile foundation.

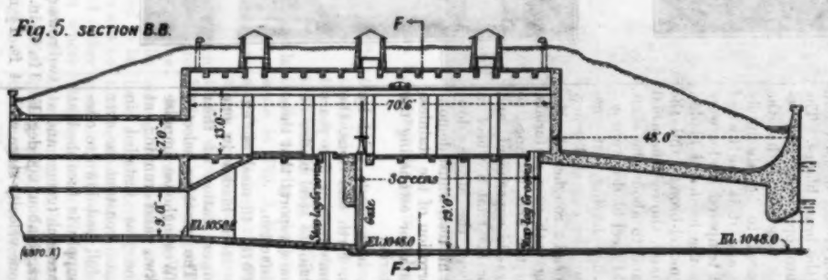
When the submerged sections of the aqueduct were built on solid soil and were covered by backfill of light specific gravity, special care had to be taken to insure permanence and stability for the aqueduct, full or empty, for often the ground water level was above the arch of the aqueduct and the backfill materials being soft, light and lacking in cohesion, had little value except to protect the aqueduct from frost, and special constructions had to be adopted to guard against the flotation of the aqueduct, or its bursting from internal pressure. This section is shown in Fig. 2, annexed. In some places the soil was strongly impregnated with sulphur, alkali and other salts, which might have an injurious effect on the concrete. In these places special care was taken to drain the trench thoroughly and permanently.

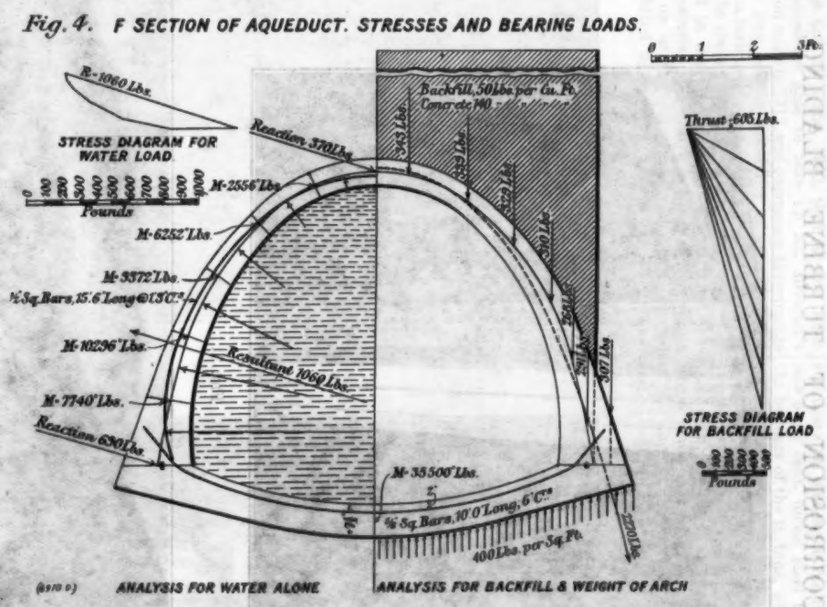
Intake.—As the water is derived from a comparatively shallow lake in a region where the temperature falls to 50 deg. below zero in the winter and ice forms 4 ft. thick on the surface of the water, special construction was necessary to insure the proper and continuous operation of the intake. It was designed with great care and consists substantially of a reinforced concrete gate house and screen chamber built in an excavation dredged to a depth of about 20 ft. below water level. The walls extend above the high water elevation and are enclosed by an outer bulkhead which retains

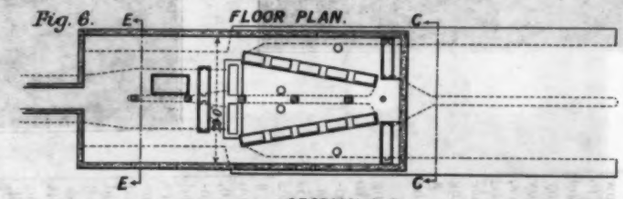
AQUEDUCT FOR THE NEW WINNIPEG WATERWORKS.

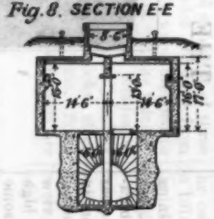
MR. JAMES H. FUERTES, CONSULTING ENGINEER, NEW YORK.

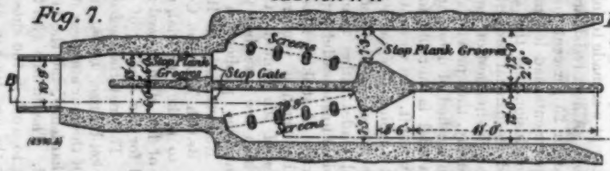


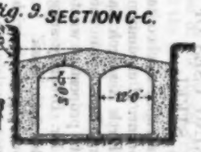












a heavy thick covering of earth protecting it from frost. The gate-house is connected to the end of the aqueduct on one end and on the opposite end has a wide incased channel with a gravel bottom, 30 ft. below water level, between two rock ballast dikes 180 ft. apart on centres, and about 200 ft. long. The top of the invert entrance is submerged 6·25 ft. at low water to prevent the possible entrance of cold air or the formation of ice in the entrance.

The copper wire screens of ½-in. mesh have a total area of 700 sq. ft. and are backed by a screen with 1-in. mesh in front of which there is a set of vertical steel racks with 1½ in. spacing; a second set of metal screens, with six meshes to the inch, stands behind the other screens, thus forming three barriers to exclude undesirable material. The screens are lifted for cleaning by a chain hoist running on an overhead track. Inside the screen-house, below the screen there is provision for dropping an inspection boat into the aqueduct. Boat entrances are also provided in the Falcon River and at each of the inverted syphons. The intake is illustrated in Figs. 5 to 9, annexed.

(To be continued.)

GEAR DATA.—A brochure of 16 pages has come to hand containing an excellent selection of data for tooth gears. The little book is compiled by Captain S. Bramley-Moore, M.C., M.I.Mech.E., of Messrs. Bostock and Bramley, Netherton, Huddersfield, by whom it is issued. The papers open with rhymes explanatory of the various terms used in connection with gearing problems, and giving many of the rules required. There follow several pages of definitions and formulæ in the most concise form possible, for circular and diametral pitch, and for spur, helical, bevel and worm gearing. Towards the end are given tables of dimensions, from teeth of standard pitches up to circular pitch 3, diametral pitch 1, and module 24. These tables are followed by pitch conversion formulæ. The pamphlet also describes briefly the concentric speed transformers which the firm above named has lately brought out.

SOME ENGINEERING USES OF STAINLESS STEEL.

Stainless steel, which is an alloy steel containing from 12 per cent. to 14 per cent. of chromium, was discovered at the Brown-Firth Research Laboratories, Sheffield, by Mr. Harry Brearley, in the year 1912, and in a report on its properties written in the October of that year, Mr. Brearley suggested its use for the blading of steam turbines. In view of turbine builders' disastrous experience with high nickel steels it is, however, not surprising that some time elapsed before any attempt was made to follow up Mr. Brearley's suggestion. A high resistance to corrosion had been claimed for 25 per cent. nickel steel; and laboratory experiments had led many turbine designers to the conclusion that this alloy also possessed the required mechanical properties, but in both respects the material in question turned out to be wholly untrustworthy, thus proving once again that the only certain method of determining whether or no a new material is suitable for a particular use is to actually use it. In view of the facts above recalled most turbine designers preferred to put up with the known evils attending the use of corrodible steel blades rather than to venture on costly and possible unsuccessful experiments with the new material. A striking illustration of the risks attending such a venture is afforded by the experiences of the United States Navy with other alloys, which are described in a paper of which we commence publication on page 615 of this issue. Nevertheless, in 1916, Mr. F. Samuelson, of the British Thomson Company, Rugby, determined to make the trial, and with the consent of one of his clients used five different kinds of material for the blading of one wheel of a steam turbine. The materials selected were phosphor-bronze, nickel-bronze, brass, mild steel and stainless steel. Of the four stainless steel blades inserted, two were hardened, and the other two hardened and tempered. The turbine with this experimental wheel was set to work in the autumn of 1916, and opened up for the first time in April, 1918, when all the blading was found to be in good condition, although the stainless steel blades were the only ones entirely free from erosion or corrosion, the greatest sufferers being the brass blades. The machine was again put into operation and re-examined last July, when it was found that the stainless steel blades appeared to be absolutely unaffected by their service, and it is worthy of note that the hardened and tempered blades were in as perfect a condition as the hardened blades. The phosphor-bronze, the nickel-bronze and the brass blades, on the other hand, showed the usual erosion at the inlet edges, and to about the same extent in all cases. The mild steel blades were not merely eroded, the inlet edge having lost one-sixteenth of an inch, but were also corroded generally, the surface being uniformly roughened. Mr. Samuelson, in experimenting with new materials, quite naturally preferred in the first instance to attempt no exceptionally drastic experiment, and had accordingly selected for his trial a wheel in which the blading was short, the stresses low, and vibration absent, so that his test, whilst demonstrating the resistance to corrosion of the stainless steel blades, afforded no data for estimating the mechanical value of the material.

This lack has, however, been made good by another customer of Messrs. Firth and Sons, the makers of the steel, who some four or five years ago fitted into a turbine stainless steel blades no less than 28 in. long, and now reports that these blades have given entire satisfaction.

Subsequently Messrs. Firth themselves experimented with stainless steel blades in one of the turbines at the power station of their Tinsley works, Sheffield. The machine selected for the test was a British Westinghouse impulse turbine, rated at 2,000 kw., and running at 3,000 r.p.m. This turbine was installed in 1916, and has been in almost constant use ever since, at loads ranging from full load down to one-quarter load. The steam supply is furnished at a pressure of 200 lb. per square inch (gauge) and at a temperature which has averaged about 600 deg. F. The turbine in question has one velocity stage with two rows of moving blades with a mean diameter of 3 ft. 7½ in., followed by seven simple impulse stages, 4 ft. 1½ in. in mean diameter. We may mention that the blading originally supplied to this turbine was of nickel steel containing 0·19 per cent. of carbon and 4·71 per cent. of nickel.

THE CORROSION OF TURBINE BLADING.

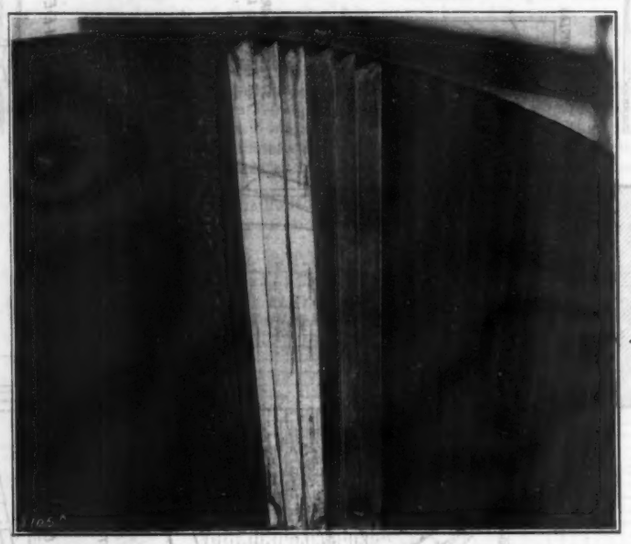


Fig. 1.

Fig. 2.

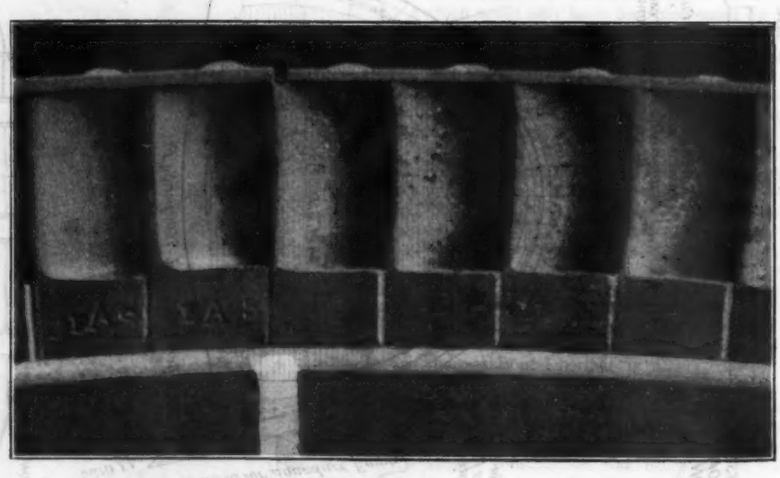


Fig. 3.

It was not till June, 1920, that Messrs. Firth were themselves able to take up Mr. Brearley's suggestion made in 1912, and commence experiments of their own on the suitability of stainless steel for steam turbine blading. During the intervening period the research staff available was in fact fully occupied in investigations bearing on other uses of the material. The turbine above described was opened up at the date stated, and experimental blades fitted to two of the wheels. The wheels chosen were respectively the velocity wheel (which constitutes the first stage of the turbine, and which is operated with steam at a high temperature, and having a high relative velocity) and wheel No. 8, which constitutes the last stage of the turbine and is fed with wet steam. In this stage, moreover, the blades are subjected to the heaviest centrifugal and bending stresses. The blades of the wheel are 7 in. long and $\frac{1}{4}$ in. wide, and of the type shown in Fig. 1, whilst the velocity wheel blading is represented in Figs. 2 and 3. Twelve of the existing blades were removed from wheel No. 8. Three were replaced by three highly-polished blades of stainless steel, having beside them three blades of the same material in the unpolished condition, whilst on the opposite side of the wheel another triplet of unpolished stainless steel blades was inserted alongside of three new 5 per cent. nickel steel blades obtained from the builders of the turbine, which were intended to serve as a standard of comparison. In the velocity wheel 24 blades were replaced by 21 blades of stainless steel (three of which were polished) and by three new blades of the 5 per cent. nickel steel. These blades were $\frac{7}{8}$ in. long by $\frac{3}{4}$ in. wide. Some of the mechanical properties of the two steels are stated below:—

	Nickel.	Stainless.
Yield-point, tons per square inch ..	25·2	44·1
Maximum stress, tons per square inch	34·7	54·5
Elongation, per cent.	32·0	20·0
Reduction of area, per cent.	61·0	59·7
Brinell hardness number	149	255

The respective micro-structures of the two steels are represented in Figs. 4 and 5, annexed. The stainless steel contained 13·4 per cent. of chromium and 0·30 per cent. of carbon.

The turbine was recently opened up, having been in operation 3,471 hours since the new blades were fitted, and on Tuesday last week we had the opportunity of inspecting the condition of the blading. The stainless steel blades appeared to be totally unaffected by the work done. There was no corrosion, and no erosion could be detected either by the eye or by touch, the inlet edges where erosion is always most marked feeling perfectly smooth, whilst those of the new nickel steel blades inserted at the same time were materially roughened, and these blades had also suffered corrosion. In the case of the nickel steel blades originally fitted in 1916 the erosion was very visible to the eye, and the blade surfaces generally had been somewhat deeply pitted and corroded.

The photographs reproduced in Figs. 1 and 2 do not adequately represent the relative condition of the two materials. Originally there were some markings shown on the stainless steel blades in wheel No. 8, but these were due merely to oxide carried over from the preceding stages of the turbine, and were completely removed by wiping the blades with a damp rag. The surface was then found to be perfectly clean and smooth, as indicated in Fig. 1. The condition of the blading in the velocity wheel is represented to a larger scale in Fig. 3, but nevertheless the photograph still fails to do justice to the stainless steel blades, which were perfectly smooth whilst the nickel steel blades were much roughened. The stainless steel blades in this photograph are stamped F.A.8.

Roughening of the blades must affect the efficiency of a turbine, and it would be interesting to have comparative figures of the steam rate of the turbine above referred to in its original and present condition. Moreover, the inlet edges of the original blading in wheel No. 8 showed such signs as to make it evident that they must ultimately be entirely replaced, whilst so far as they go, the experiments with the stainless steel blades give promise of an indefinite life and of maintained efficiency, a desideratum

Fig. 4. Nickel Steel; Magnification 500.

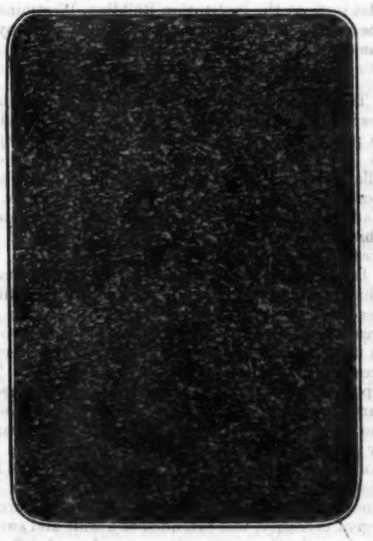


Fig. 5. Stainless Steel; Magnification 500.

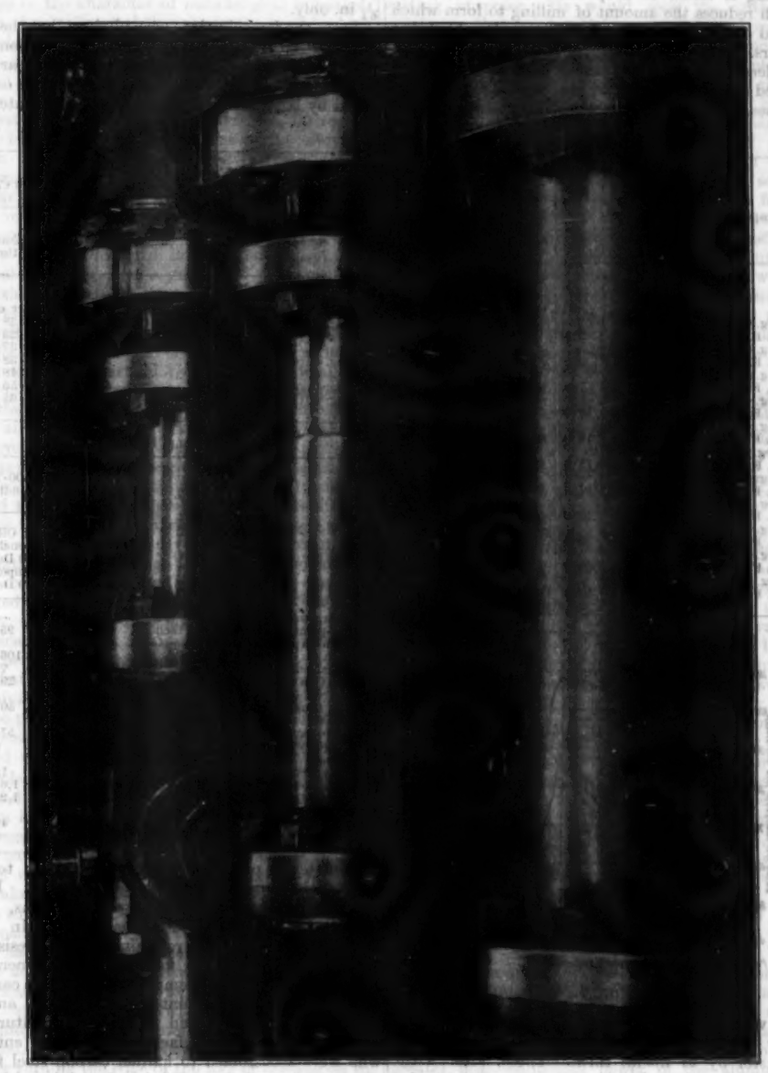


Fig. 6. Stainless Steel Rams for Hydraulic Pump.

which station engineers have been in the past somewhat lax in demanding. In the Navy it is said that there has been no erosion with phosphor-bronze blades, but it must be borne in mind that naval vessels do not work at anything like full power, save for relatively brief periods, and, moreover, steam speeds are generally much lower than is usual in land practice. Mr. Samuelson's experiments, in any case, show very clearly that the stainless steel is superior to the phosphor-bronze. The material for turbine blading is rolled to a special "rhubarb section," which reduces the amount of milling to form which would otherwise be necessary. It may be added that Messrs. Firth are catering for the wants of turbine builders in other directions, and are supplying bossed discs for turbine wheels pressed out of solid cheeses. Amongst the work now in progress

TABLE I.

Tempered.	Yield-Point.	Max. Stress.	Elongation.	Reduction of Area.	Impact.	Brinell Hardness Number.
	tons per sq. in.	tons per sq. in.	per cent.	per cent.	ft.-lb.	
100 deg. C. (212 deg. F.)	101·8	107·1	2·0	1·4	—	477
200 deg. C. (392 deg. F.)	100·4	106·7	3·0	4·9	—	477
300 deg. C. (572 deg. F.)	86·6	102·7	7·5	22·9	—	450
350 deg. C. (662 deg. F.)	87·9	104·3	10·0	30·5	—	450
400 deg. C. (752 deg. F.)	96·0	105·0	12·0	36·2	15, 6, 10	477
500 deg. C. (932 deg. F.)	98·5	107·1	15·0	44·0	6, 6, 10	450
550 deg. C.(1,022 deg. F.)	72·8	79·7	17·0	50·3	24, 23, 20	325
600 deg. C.(1,112 deg. F.)	51·4	60·5	20·0	55·8	25, 28, 26	269
650 deg. C.(1,202 deg. F.)	43·3	52·3	22·0	62·6	69, 70	235
700 deg. C.(1,292 deg. F.)	41·3	49·1	26·0	64·7	70, 69, 61	223
750 deg. C.(1,382 deg. F.)	36·6	45·9	30·0	70·7	79, 80, 83	202

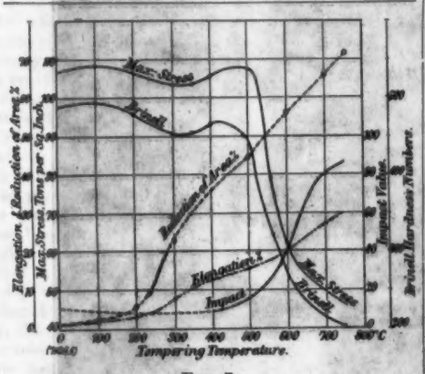


FIG. 7.

are wheels for 15,000 kw. impulse turbine. They are produced from a billet 36 inches in diameter by 21 inches thick. These, after withdrawal from the reheating furnace, are put under a 4,000 ton intensifier forging press of the latest design, and forged at one heat into a double-bossed turbine bucket wheel, 84 in. in diameter by 4½ in. thick on rim, the bosses being 22 in. in diameter, and the thickness through the boss 6½ in. This operation is completed in about 20 minutes, and the fact that the wheels are forged at one heat ensures an even temperature which is very essential in dealing with this vitally important part of a turbine. Prior to the installation of this special plant the wheels, being extremely thin in section, cooled very rapidly, and consequently several heats were frequently required to complete the forging operation. The table on which the work is done is operated by hydraulic pressure, and is capable of dealing with wheels up to 10 ft. in diameter. Messrs. Firth have, moreover, succeeded in casting steel guide blades into cast steel nozzle boxes, which should promote the present movement towards higher pressures and higher temperatures.

Another interesting engineering application of stainless steel is to the rams of hydraulic pumps. The photographic view, Fig. 6, page 593, shows the rams of a three-throw hydraulic pump built by Messrs. Davy Brothers, of Sheffield, which has been at work since 1915 supplying water at a pressure of 1,000 lb. per square inch. One of the rams is stainless steel and the others of phosphor-bronze. The stainless steel ram has not merely maintained its original polish much better than the bronze rams, but has suffered much less wear; whilst the phosphor-bronze rams have been reduced in diameter by $\frac{7}{64}$ in., the wear on the stainless steel ram has been $\frac{3}{64}$ in. only.

From the foregoing it is very obvious that the new material must find many useful applications in heavy engineering work, and some further particulars as to its properties so far as they can be established by laboratory experiments will be of interest.

TABLE II.

Temperature of Test.	Structural Carbon Steel.			Stainless Steel in the Well-Tempered Condition.			Stainless Steel (Knife Temper).		
	Max. Stress.	Elongation.	Reduction of Area.	Max. Stress.	Elongation.	Reduction of Area.	Max. Stress.	Elongation.	Reduction of Area.
	tons per sq. in.	per cent.	per cent.	tons per sq. in.	per cent.	per cent.	tons per sq. in.	per cent.	per cent.
Ordinary temperature	27·2	38·0	61·0	49·02	22·0	55·0	109·0	7·0	16·0
300 deg. C. (572 deg. F.)	32·5	23·2	55·8	49·0	30·0	58·0	108·3	8·8	13·0
400 deg. C. (752 deg. F.)	25·2	37·2	68·5	43·5	21·0	56·0	101·5	4·0	6·6
500 deg. C. (932 deg. F.)	20·0	38·0	73·0	35·5	22·5	65·0	87·0	8·8	27·5
600 deg. C. (1,112 deg. F.)	12·5	48·0	86·0	21·7	31·2	88·7	32·2	19·2	70·1
700 deg. C. (1,292 deg. F.)	6·8	56·0	93·0	13·8	33·0	89·5	14·15	32·8	72·8
800 deg. C. (1,472 deg. F.)	4·0	65·0	96·0	6·54	69·6	98·0	6·80	71·0	98·0

TABLE III.

Nature of Test.	50-Ton Condition.	100-Ton Condition.
	Water-Quenched at 650 Deg. C. = (1,202 Deg. F.)	Oil-Quenched at 950 Deg. C. Tempered at 250 Deg. C.
Tensile :—		
Elastic limit, tons per square inch	30·0	—
Yield-point, tons per square inch ..	39·8	95·0
Maximum stress, tons per square inch	49·02	106·7
Elongation, per cent.	22·0	7·0
Reduction of area, per cent. ..	55·0	29·5
Torsion :—		
Yield, tons per square inch ..	28·07	50·3
Probable maximum stress, tons per square inch	32·9	57·4
Degrees twist	473	69
Izod impact, foot-pounds	48	8
Arnold, reversals	168	152
Stanton, blows	4,281	1,651
Sankey, foot-pounds	1,440	1,240
Hardness :—		
Brinell hardness number	217	444
Shore hardness number	35	64

The material owes its properties in part to its composition and in part to its treatment. It is supplied by the makers in three conditions, viz., hardened, machinable and malleable. In the malleable state, whilst retaining its rust-resisting properties it is suitable for press work generally. It can be hardened and tempered similarly to carbon steel, but the change-point is much higher, and it took some little time and no little expenditure of energy to impress this fact on makers of cutlery who were accustomed to harden carbon steel from a temperature of about 760 deg. C., whilst with the stainless steel it is necessary to attain a temperature of about 950 deg. C. If this precaution is taken there is no difficulty in securing razor hardness.

After hardening, stainless steel maintains its strength up to an incipient red heat, as is shown in Table I.

Moreover, as shown in Table II, the stainless steel retains its strength in a remarkable way when tested at increasing temperatures.

The results of some other mechanical tests are recorded in Table III.

In Fig. 7 the variation in the properties of the steel as tempered at the various temperatures is represented by curves.

As the result of exhaustive researches, the specification for the composition of the steel now calls for much smaller variations in the composition than were originally thought permissible, and to secure this the steel is all electrically melted and refined. The makers have five electrical furnaces in operation, of which two are each of 10 tons capacity. The steel is cast in 12-in. ingots, and these are machined before being further worked up, thus ensuring that any impurities dissolved from the mould shall be removed. Stainless steel has a somewhat lower conductivity than structural steel, and consequently requires more careful heating. Its weather-resisting properties appear to be perfect. Knives which have been lost down a drain for months, and subsequently recovered, show their original polish on being merely wiped clean. It resists attack by nitric acid at all concentrations. Exposed to an increasing temperature, it scales less than any other steel, and though it shows temper colours, these only make their appearance at much higher temperatures than with ordinary carbon steels. For forging, the temperature should be between 1,150 deg. and 900 deg. C., though it is not impossible to work it below the latter limit. It can be electrically welded, but welds cannot be made with a smith's fire, as layers of chromium oxide form and prevent the union of the surfaces.

THE INSTITUTION OF MECHANICAL ENGINEERS.

THE first ordinary meeting of the 1921–22 session of the above Institution was held on Friday last, the 21st inst., at the Institution Building, Westminster, the president, Captain H. Riall Sankey, occupying the chair.

SOME ALLOYS OF ALUMINIUM.

The formal business of the meeting having been despatched, the president called upon Dr. Rosenhain to present the "Summary of the Eleventh Report to the Alloys Research Committee on Some Alloys of Aluminium (Light Alloys)," by Dr. Walter Rosenhain, Mr. Sydney L. Archbutt, and Mr. D. Hanson, of the National Physical Laboratory. This summary we reprint in another part of the present issue (see page 613).

Dr. Rosenhain said it was the third occasion on which he had presented a report of the Alloys Research Committee to the Institution. He felt great satisfaction in presenting the Eleventh Report, as many times during recent years the prospect of presenting it had seemed very distant indeed. The report differed in many ways from its predecessors, partly on account of the long lapse of time since the preceding report had been presented and partly by reason of the circumstances under which the work had been carried out. Previous reports had dealt with a systematic and detailed study of one group of alloys. The present, under pressure of urgent necessity, was extended to a wide and sweeping investigation over a large number of different groups of alloys. Therefore, although in some cases the study had not been so intense in detail as it had been with earlier work, it had been necessary to deal with an immense range of materials, involving the accumulation, over the eight or nine years, of an enormous mass of data. The boiling down of these data into a volume of the size of that which contained the complete report had not proved the least part of the work.

Dr. Rosenhain referred to the fact that the present research differed from its predecessors in the number of persons engaged in carrying it out. The previous report had been mainly the work of two or, at most, three people, namely, Mr. Archbutt and himself, who, with the assistance of one or two junior members of the staff, carried out the details. The work described in the Eleventh Report was, however, the product of an organised research, in

which, in all, more than 30 people took part. It was organised and co-ordinated with the aid of the whole staff of the Metallurgical Department of the Laboratory. That staff and that organisation had grown very considerably before the war, and found particular usefulness under the pressure of events. For himself and on behalf of his colleagues whose names appeared on the report, he would say that they made no pretence to having done the whole of the work; they were really only the senior members of an organised staff, and only claimed authorship of the report in that capacity. He desired that point to be clearly understood. A series of detailed acknowledgments appeared in the report. The Light Alloys Sub-Committee of the Advisory Committee for Aeronautics had played a large part and it was, perhaps, superfluous to say that all efforts were pooled; throughout, his department had received the most generous and liberal assistance from everyone concerned. Dr. Rosenhain then proceeded to outline the contents of the report, much as indicated in the summary printed elsewhere in this issue.

The President, in opening the discussion, said it was remarkable that so few of the alloys investigated had come into real practical use. In all of them the greatest difficulty had been encountered in breaking them down, in rolling and in other processes for making them into rod, sheet or wire. On this matter not only did the report record the success attained, but also the difficulties which had arisen. That was a very commendable feature. In connection with the delicacy of the processes adopted in the making of the sheet, bar and wire, and the sensitiveness of the heat treatment, he wondered whether such delicacy of treatment was possible in the ordinary routine of works. He trusted manufacturers would speak on the report from this point of view. The Institution was, in essentials, an institution dealing with practical mechanical matters, and felt the importance of bringing the results of its researches into practice.

Sir John Dewrance, K.B.E., Vice-President of the Institution and Chairman of the Alloys Research Committee, was the next speaker. He said some members of the Institution of Mechanical Engineers might regard the research as a matter which should more appropriately be placed in the hands of the Institute of Metals. It was, however, started long before the Institute of Metals was formed.

Anyone reading the report might at first think that the money of the Institution had been squandered by the carrying out of the very numerous experiments, but that was not the case. The real position was that the Institution of Mechanical Engineers' Committee found the nucleus on which the enormous research had been built up. The Government, as Dr. Rosenhain had pointed out, had the foresight to see that the research would prove very helpful in relation to the aeroplane and flying machines generally, and before the war they had taken part in the matter. When the war broke out the question became urgent, and large sums of money were spent on the investigation. He felt a pride in the collective results of the mass of work done. He did not pretend that the Institution paid for it all, but it was all done under their auspices. The report represented a large amount of work and material, costing an amount of money which the Research Committee could not have provided, but which the foresight of the Institution had initiated.

The Report itself required most careful reading, and must be of great interest to all who worked with light alloys. It should not be forgotten that the future of mechanical engineering was likely to take a great stride in that direction. He would therefore urge upon the young mechanical engineer that he must not believe that light alloys did not constitute a mechanical engineering subject; light alloys might become the raw material of some of the most important structures yet to be made. The Committee desired to complete their labours, if possible, and then they might put before the Council the proposition that, having finished their work, the Institute of Metals should in future deal with subjects of the kind. There was no desire to trench upon the province of the Institute of Metals, but merely to complete the research in progress, which the National Physical Laboratory had assured the Committee was not yet finished.

Professor Thomas Turner spoke next. He said it had to be recognised that each of the reports presented to the Alloys Research Committee had, in its turn, been a classic dealing with particular parts of the subject. Great as had been the work of the Institution in various directions, there was none in which they had conferred greater benefit upon the metal industries than through the Alloys Research Committee. There had been a wonderful change in the character of metallurgical investigation and metallurgical thought in the period which had elapsed since the first report was presented. At that time aluminium was a comparatively unknown metal, while at one works, scarcely a stone's throw from the University with which he was connected, there were, during the war, 50 tons a week turned out regularly of one of the alloys to which reference had been made in the Eleventh Report. As the result of this investigation and similar investigations, large quantities of alloys were made, and were of the utmost importance to this country during the recent period.

The report contained information of a fundamental character, and a great deal of information published for the first time. In looking over other reports and researches of the kind, it would be difficult to find one which brought out so many details of importance, or which had a higher theoretical and practical value. In the metallurgy of iron and steel it was understood that by the addition of certain materials, such as chromium, &c., alloys were formed having characteristics of the greatest value to mankind. One of the great merits of iron was its susceptibility to transmutation into so many other different materials. It was now found that aluminium possessed properties similar, in this respect, to iron, and out of the simple metal, alloys could be produced which would retain their strength at relatively high temperature, would have high conductivity when required, and could be worked cold so as to give high tensile strength; alloys, also, which would age so as to give improved physical properties, retaining their properties for a long period of years. Many people had been afraid of what would happen as a result of the ageing of aluminium. Certain alloys had been made which fell to pieces. Now metallurgists knew what things to avoid and knew how to produce alloys which would retain their properties.

Professor Turner continued that, during the war, great difficulty had been experienced by one large works in consequence of the fact that aluminium castings would not turn readily; proving very hard. The cause appeared to be the presence of iron, taken up from the unprotected iron pot in which the aluminium was being melted. Side by side with this difficulty of turning or cutting, there was a considerable loss of metal in the form of dross. This had all been explained by the theoretical work done at the National Physical Laboratory, and it was known that there was a definite compound of iron and aluminium which was insoluble in aluminium and therefore separated, as it was formed, in the shape of hard particles in the mass, either turning the edge of the tool or floating on the surface in the form of dross.

In conclusion, he might say, on behalf of the Institute of Metals, that there was no Institution to which the results of such researches as those under discussion could be more valuable; and that it was with no feeling of jealousy that the Institute of Metals looked upon the work of the older and larger Institution. The Institute of Metals appreciated greatly the work that was being done, and had no desire that that work should, as foreshadowed by Sir John Dewrance, be brought to a premature conclusion.

Dr. A. G. E. Gwyer, of the British Aluminium Company, spoke briefly, as, although he had been frequently in contact with the authors of the report, he had not had sufficient time to study it. On behalf of Mr. Morrison and his colleagues he would say that any help they had been able to give the authors had been very gladly rendered. With regard to the various elements added in casting, such as iron, molybdenum, tungsten, chromium, vanadium, &c., he would ask whether the addition of iron to aluminium castings was beneficial and safe or was not so. In this country, at all events, there had been a bias against the addition of iron in amounts larger than those ordinarily met with in commercial metal. He had lately been much struck by American practice, and had found, from samples which had been sent to him to investigate, that in aluminium castings a relatively high iron content was being largely used—something of the order of 1 per cent. to 2 per cent.—and there was no doubt that the iron was added intentionally for casting purposes. He would seek the authors' opinion on that point, which was important because of the large amount of aluminium used in founding.

In relation to the use of the aluminium for piston work, he believed that no measurements were given in the report of coefficients of expansion. Such coefficients would be very useful for comparing one alloy with another. The question of preliminary working was of importance. In the introduction of the alloys on a commercial scale, the question of whether it was necessary to forge prior to breaking down became very important. He was aware that these alloys had been successfully broken down, notably the "3/20" alloy, but he had always understood that some preliminary working was necessary prior to forging, or extrusion. That was an aspect of the subject that would need careful attention at the hands of possible producers, owing to the narrow range of temperature through which the alloys could be worked.

Engineer Rear-Admiral R. B. Dixon, who spoke next, gathered from the report that the problem of aluminium alloys had, in its metallurgical aspect, been more or less solved; it now remained with the engineer. The Admiralty were, of course, very much interested in aluminium alloys, on account of the many uses to which they could be put. Speaking for the Engineering Department, he was particularly interested in aluminium alloy pistons for Diesel engines, and the Department had carried out some trials of aluminium pistons in submarine and other Diesel engines of the fast-running type. The composition used by the Admiralty varied from 2½ per cent. to 3½ per cent. of copper, 1 per cent. to 1½ per cent. of nickel, and ½ per cent. to 1 per cent. of magnesium, and was somewhat similar to the "Y" alloy, save that in every case the percentages were less. Before the end of the war pistons of these alloys had been fitted in submarines. Unfortunately the submarines were not in the post-war fleet, and the Admiralty experience had not proved as great as had been hoped. Recently, however, they had fitted aluminium pistons in other submarines, now in the post-war fleet, and so far they had been quite satisfactory, but he could not say whether they would continue to be so. Difficulties had arisen. These difficulties were not, however, due to the composition of the pistons, but to the way in which the latter were fitted.

In the Summary of the Report it was stated that the gain in efficiency in internal-combustion engines which resulted from the use of light alloy pistons was due, not so much to any small saving in weight of the reciprocating parts, as to the greater heat-conducting power of the aluminium alloy. He presumed that remark referred to the aeroplane engine. From the point of view of the Diesel engine thermal conductivity was not of so much account; the weight was of much more importance, because the stresses due to inertia in the case of heavy pistons were of serious consideration, and with the lighter pistons the engines were found to run more satisfactorily. He was inclined to think that that point must also affect the aeroplane engine.

Mr. A. E. L. Chorlton observed that he had taken the opportunity to follow Admiral Dixon because the latter had spoken particularly on the naval piston. The mixture of the Admiralty alloy was very similar to the "Y" alloy, and was in use as soon as, or even earlier than, the 12 per cent. or 11 per cent. copper became the standard for the aeroplane piston. Curiously enough, in the end it had proved to be the better of the two. The earliest piston of this material (made in 1917, he believed) ran from the beginning without giving any trouble. As Admiral Dixon had said, the main advantage derived was

from reduction in weight and reduced inertia forces. From the point of view of service in pistons for Diesel engines, its ultimate value would reside in the fact that a cylinder as large as 20 in. in diameter could be made and used without water-cooled pistons.

He would ask the authors of the report whether the aluminium-silicon alloys were all alloys that had been built up at the National Physical Laboratory. When he was on the continent in May last, he found that engineers there had great belief in the merits of the aluminium-silicon alloy. An alloy—of which he had been unable to learn the constituents—had, he understood, been invented and originated at the Zeppelin Works at Ludwigshafen, and had been improved by a firm in Westphalia. This alloy was in a state to be largely used, because of its considerable strength for all sorts of purposes. He had endeavoured, unsuccessfully, to procure a sample, but he believed that the Air Ministry had almost succeeded in doing so. The strength of the alloy was about 12 tons. So far as he was aware, that alloy and the electron alloy were the two materials used for pistons on the Continent. Another point was that up to the present time aluminium had almost always been used for purposes where the strain or stress was a small one, never a high one. He would ask Dr. Rosenhain what prospect the latter could see in the near future for "40 or 50-ton" aluminium connecting rods and crankshafts. If there was reasonable hope of an aluminium alloy being used for that purpose, it would be possible to have aeroplane engines weighing ½-lb. per horse power.

Mr. S. Payne, of the Royal Airship Works, said that with the assistance of the National Physical Laboratory, he had found in the "Y" a working alloy which could be used in any foundry and rolling plant with modern appliances. The "3/20" was a good alloy, and it was possible to do almost anything with it, but for airship use it corroded too badly. Nevertheless, he thought that Dr. Rosenhain had, if anything, understated its possibilities. At the airship works it had been possible regularly to obtain 25 tons, 26 tons or 27 tons per square inch with it, with elongations of 15 per cent. to 20 per cent. on 2 in., depending on the thickness. It was not found difficult to roll, nor did difficulties arise in relation to temperature. It was the practice in the airship works to do the forging down to 30 per cent., round about 370 deg. to 400 deg. C., in two heats, and no temperature trouble occurred. There was difficulty, however, in rolling below 16 gauge, and the alloy under discussion wanted some 25 per cent. to 30 per cent. more passes than were required when rolling "duralumin." This was not regarded as a serious hardship.

The "Y" alloy could easily be rolled down to 0·01 in. In addition to the work done by the authors with this alloy, "Y" had been used in the foundry and rolling mill in fairly large proportions, on a businesslike scale, and had been found a success. The authors had stated in their summary that it was best to add the magnesium in the form of pure metal cut into fairly large pieces. His experience had been that it was best to use pieces of about the size of a walnut; no trouble then arose. Mr. Payne stated, further, that he had checked "duralumin" and "Y" dozens of times, and had invariably found that they came well up to specification. The range in the ultimate tensile strength of those two alloys was narrower than that the Admiralty accepted in the case of mild steel. With mild steel, as used in ships, there was a 4-ton range (between 26 tons and 30 tons) per square inch; but, where a definite tensile strength was required the alloys mentioned would give 26 tons or 26½ tons, with a range of not more than 1 ton. They had been less successful in the casting of the "Y" alloy, with which they obtained only 18 tons to 19 tons per square inch.

Mr. H. B. Weeks, of Messrs. Vickers, Limited, Barrow-in-Furness, referred to the comparisons made with regard to "duralumin," and pointed out that the sample of "duralumin" subjected to compression test was comparatively soft, whereas the sample of the high-tension alloys was in a hard state. "Duralumin" would, however, give 35 tons per square inch as easily as 26 tons per square inch. There were four alloys of "duralumin," each possessing its own specific properties, and a "duralumin" could be provided which would be harder than an alloy giving a greater elongation with a lower tensile strength. His company had done a great deal of work in aluminium alloys generally, especially with regard to applications for casting. At Barrow they had carried out tests and trials of aluminium alloy pistons for submarine engines, with diameters of about 14 in. to 15 in., and it was recognised that while, in a small high-speed engine, any reduction in weight of piston might be of the utmost importance the difference was less essential in larger engines, where the inertia of the reciprocating parts was not a deciding factor. In such cases an increase in revolutions, with a light piston to bring the stress in the crank head bolts up to the original limit, might cause increase of stress and wear in other parts. In aluminium alloy pistons it was necessary that clearance should be greater than with cast-iron. The increase in clearance did not need to approach the difference in rate of expansion over a given increase of temperature, the piston clearance being made up of two portions, one portion to allow for the expansion of the piston and the other portion to allow for the thickness of the oil film, which varied inversely as the temperature.

Aluminium alloy pistons, owing to their increased rate of conductivity and generally increased bulk, did not get so hot as cast-iron pistons, and the greatest advantage in the use of aluminium alloy pistons was the lower running temperature, which in the case of a petrol engine enabled a higher compression to be used without pre-ignition, and also, by lowering the suction temperature, increased the charge density, and therefore the mean effective pressure and horse-power. Lightness had a secondary advantage in allowing the engine to run smoothly at a somewhat higher speed.

Dr. Rosenhain had referred to the hardening of "duralumin" after a considerable number of years. He (the speaker) had not found this to be the case. He had known the material for some twelve or fourteen years, and samples in his possession at the present time gave exactly the same test results as when first made—that was to say, after the period for normal ageing, about a fortnight. He was therefore interested in Dr. Rosenhain's discovery that the material hardened even after a number of years, and he could only suppose that the circumstance was due to more efficient annealing for a longer period at normal temperature.

Referring to the president's remark in connection with the delicacy of treatment required for the alloys, he had not, in practice, found any difficulty. It was a question of accurate and correct working; instructions had to be carried out. Alloys had certain properties only to be brought out by certain specific treatment. In the works to which Professor Turner had alluded as turning out many tons of high aluminium alloy during the war, no difficulty had been experienced. The workmen were ordinary, although trained, workmen, and with proper temperature control there was absolutely no trouble found. Mr. Week's remarked, finally, that he understood a firm in Manchester, using an alloy in die casting, had stated that their alloy contained 4 per cent. of iron.

The discussion was then adjourned until to-day, the 28th inst., and the president announced that the Thomas Hawksley Lecture, entitled "Power Transmission by Oil," would be delivered by Dr. H. S. Hele-Shaw, F.R.S., Vice-President of the Institution, on Friday, November 4, at 6 p.m.

THE MANUFACTURE OF SMOKELESS FUEL.

MESSRS. LOW TEMPERATURE CARBONISATION, LIMITED, BARNSLEY.

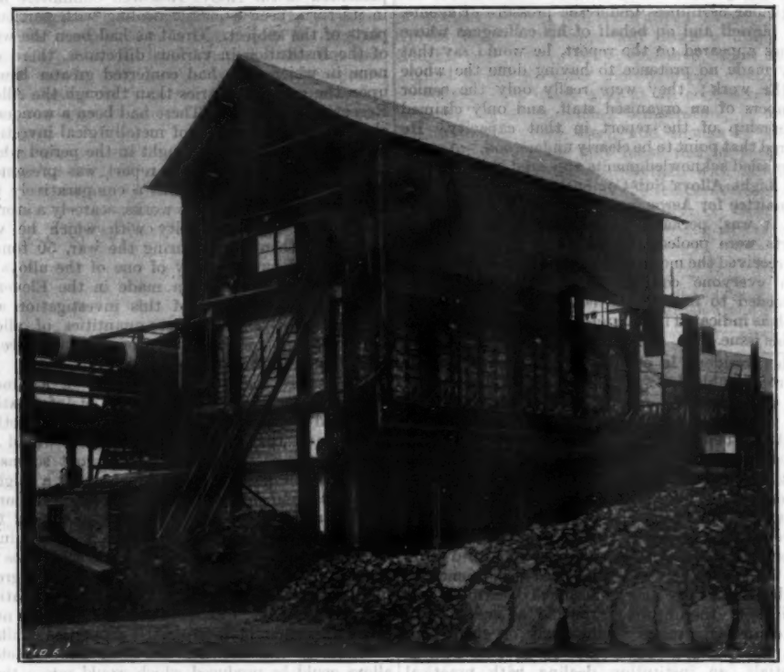


Fig. 7. General View of Retort House.

THE MANUFACTURE OF SMOKELESS FUEL.

Nothing short of a fuel which will not make smoke under any conditions will effectually prevent smoke production and eliminate the dirt and gloom which are associated with it. It was realised many years ago that such a fuel might be obtained by distilling off the smoke-forming constituents of coal, recovering them in the form of gas and valuable oils, and leaving the coal in such a state that it would burn freely but without smoke. In ordinary gasworks practice the distillation of the coal is carried out with the primary object of securing the greatest possible yield of gas, the coke produced in the process being regarded in the light of a by-product. To get the maximum yield of gas, distillation has to be conducted at a temperature of

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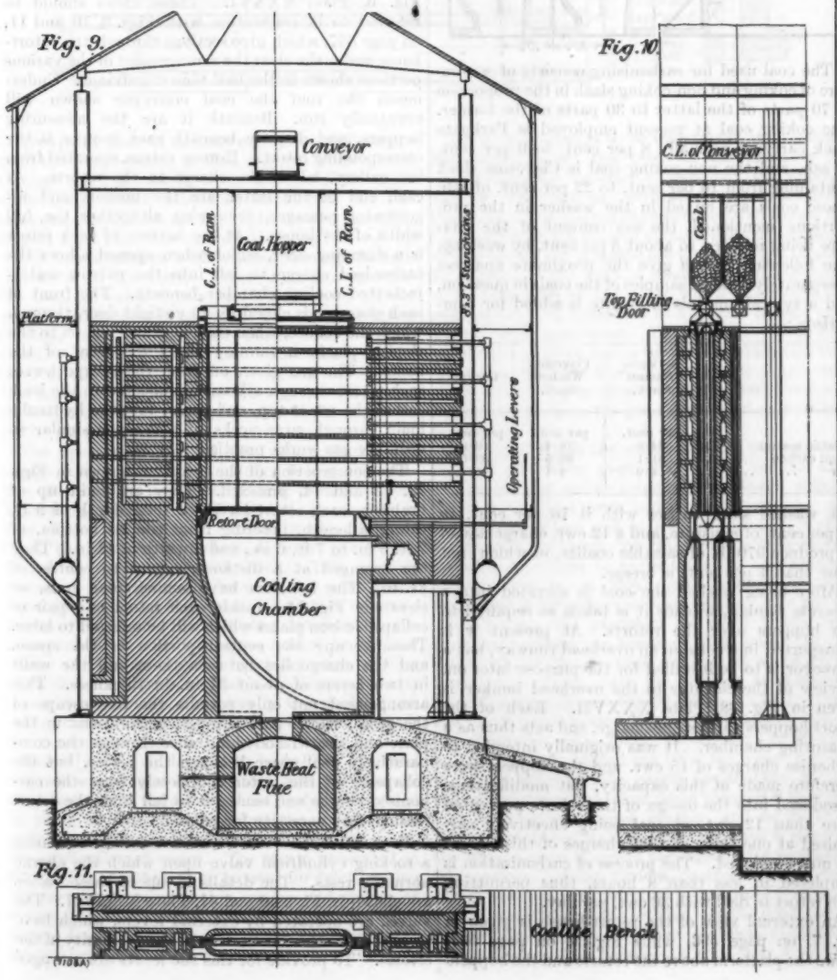
FIG. 8. HOPPER CHARGING GALLERY.



about 1,000 deg. C., and as at this temperature the whole of the volatile matter is driven off, the coke which remains is difficult to ignite, and cannot be burned by itself as a domestic fuel. It is also unsatisfactory for industrial steam raising, and can only be burnt efficiently when a strong draught is available. To render the solid residue, which remains after distillation, generally satisfactory as a fuel, it is necessary that it should still retain a certain amount of volatile matter, and this can be brought about by carrying out the distillation at a comparatively low temperature, say about 600 deg. C., so that only the most easily removable components of the coal are driven off.

When once the problem is stated, it might be thought that there would be no particular difficulty in carrying out a distillation of this kind, especially in view of the vast amount of experience accumulated in connection with the distillation of coal in gas works and coke ovens. But the fact remains that, simple as it appears, the low-temperature distillation of coal presents unexpected difficulties, and vast sums of money have been expended in endeavours to effect it on a commercial scale. One of the troubles has been that the resulting fuel has been soft and friable in nature, unsuitable for transportation and productive of wasteful dust. Otherwise it has been too completely coked to burn readily. The difficulty of getting heat into the mass of the charge on account of the necessarily low temperature of the furnaces has involved the use of narrow retorts in which no portion of the coal was more than a few inches from the retort walls. In such retorts the coal was found to jamb as it expanded during the process of coking, and violent means often had to be employed to discharge it. Consequently much of it was broken up into dust in the process, which was tedious and expensive and fraught with injury both to the fuel and to the retorts. Many other troubles occurred in practice. The retorts could not be made perfectly gastight, and some of the gases given off by the coal therefore found their way through the retort walls and burned in the furnace. This made the furnace temperature uncontrollable, and it was liable to rise sufficiently to over-carbonise the charge and to reduce the quality of the gas recovered. Furthermore, even if the carbonisation could be carried out exactly as desired, and the charge could be removed from the retort without being pulverised in the process, there still remained the problem of quenching it. Being only semi-coked it burst into flame immediately it was brought into contact with the air, and drenching it with water, as is done in the case of gas works coke, was found to spoil the nature of the fuel.

It will thus be evident that the conversion of coal into a smokeless fuel on a commercial scale by means of low temperature carbonisation was by no means so easy a task as might have been expected, and a long series of disappointments befell those who were attempting to develop the process. Nevertheless the work was persisted in, as it was realised that if success could be obtained, the industrial importance of treating coal, and particularly slack and almost worthless coal, in this way might be very great. It is generally admitted that by a process of low temperature carbonisation, a ton of average bituminous slack may be made to yield about 20 gallons of heavy oil, 6,000 cub. ft. of rich gas with a calorific value of about 700 B.Th.U. per cubic foot and about 12 lb. of sulphate of ammonia. The heavy oil may be directly used as fuel for Diesel or other high compression engines of the internal-combustion type, or it may be fractionated into motor spirit, lubricating oil, fuel oil, and pitch. The solid residue of a ton of coal, after carbonisation, amounts to about 14 cwt. of smokeless fuel, suitable either for domestic or industrial use. It must be remembered, however, that a considerable quantity of heat is required to effect the carbonisation, and this, of course, has to be debited against the products obtained, a point to which we shall refer later. In spite of this, it is nevertheless clear that low temperature carbonisation permits the recovery of the smoke-forming constituents of coal in the form of valuable by-products, and their removal increases the value of the fuel for many purposes.

The works of Messrs. Low Temperature Carbonisation, Limited, at Barugh, near Barnsley, Yorkshire,

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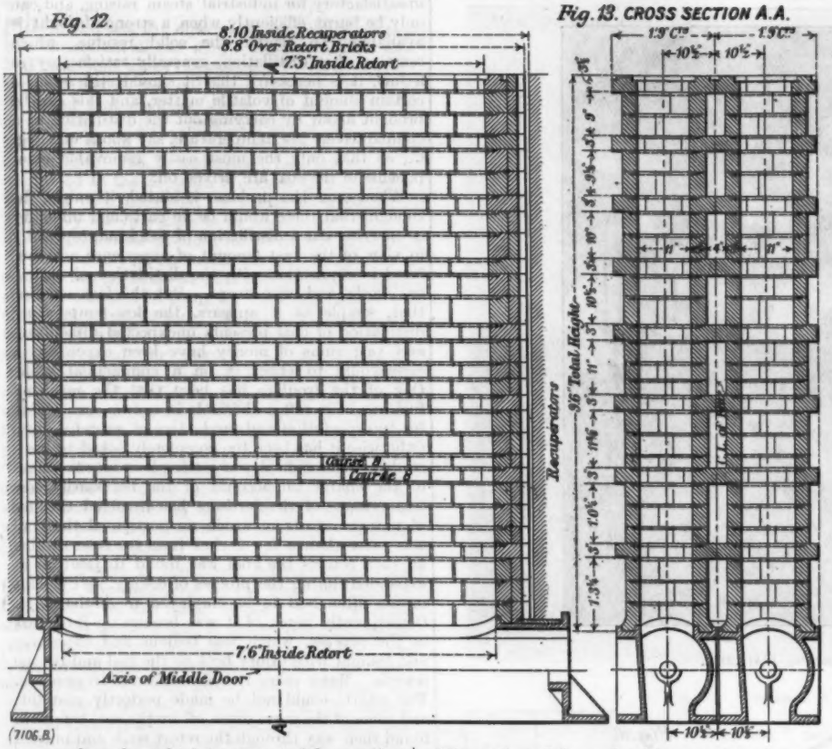

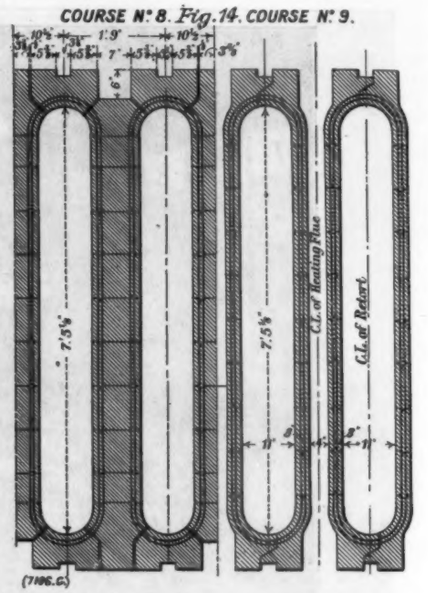

have now been brought into commercial operation and are carrying out the production of smokeless fuel on a scale sufficiently extensive to indicate that the technical difficulties of the process have been satisfactorily overcome. The company have now 20 retorts in continuous service, and are carbonising about 36 tons of coal per day. The fuel produced is a sort of semi-coke carrying only a very small proportion of breeze, and appearing amply hard enough to withstand the exigencies of handling and transport. We were assured, indeed, on the occasion of a recent inspection of the Barugh Works, that the fuel could be handled and transported with less breakage than coal, and this seemed quite possible. It burned freely in an ordinary fire grate, making a pleasant fire with very great radiant heat and with no trace of smoke. In appearance it is like semi-fused small coal sintered together in the form of slabs, and it has none of the lustre or the "scratchiness" of coke. The slabs are about 3½ in. thick, and though they sometimes come from the retort bench in pieces 2 ft. or 3 ft. across, they are more usually broken into bits of more convenient size. Outside the retort house was a pile of "Coalite" as the fuel is called, amounting to probably more than 100 tons, and the appearance of the pieces was very uniform.

The general appearance of the Barugh works is shown in Fig. 1, on Plate XXXVI, and other photographs reproduced on the same plate show parts of the plant in greater detail. The essential and most interesting feature of the works is, of course, the retort house as the washing plant, sulphate recovery plant, condensers, &c., are more or less typical of modern installations of the respective kinds. The 20 in. concrete main bringing gas from the holder to the retort bench is, however, somewhat of a novelty. This was made at the site, and the joints are caulked with hemp and then run in with cement. The works are laid out to serve, and deal with, the products of 200 retorts, and sufficient plant is actually installed to deal with 100 retorts, although only one bench of 20 retorts is as yet constructed. Each of the retorts will carbonise three 12-cwt. charges in a day of 24 hours, so that the ultimate capacity of the works will be about 360 tons of coal per day.

The coal used for carbonising consists of a mixture of coking and non-coking slack in the proportion of 70 parts of the latter to 30 parts of the former. The coking coal at present employed is Parkgate slack carrying normally 8 per cent. to 9 per cent. of ash, and the non-coking coal is Claycross slack containing from 16 per cent. to 22 per cent. of ash. These coals are mixed in the washer in the proportions mentioned, the ash content of the mixture being reduced to about 5 per cent. by washing. The following figures give the proximate analyses of separately-washed samples of the coals in question, and a typical analysis of coalite is added for comparison :—

—	Parkgate Washed Slack.	Claycross Washed Slack.	Coalite.
	per cent.	per cent.	per cent.
Volatile matter ..	34·0	36·4	10·0
Fixed carbon	61·1	58·5	83·6
Ash	4·9	5·1	6·4

The washed slack carries with it 10 per cent. to 12 per cent. of moisture, and a 12-cwt. charge is said to produce 970 lb. of saleable coalite, of which not more than 4 per cent. is breeze.

After being washed the coal is elevated into a concrete bunker, whence it is taken as required to the hoppers over the retorts. At present it is transported in trucks on an overhead runway, but a conveyor is to be installed for the purpose later on. A view of the elevator to the overhead bunker is given in Fig. 38, Plate XXXVII. Each of the retort hoppers carries one charge, and acts thus as a measuring chamber. It was originally intended to carbonise charges of 15 cwt. and the hoppers were therefore made of this capacity, but modifications introduced into the design of the retorts prevented more than 12 cwt. of coal being effectively carbonised at one time, so that charges of this weight are now employed. The process of carbonisation is completed in less than 8 hours, thus permitting each retort to deal with 36 cwt. per day.

An external view of the retort-house is given in Fig. 7, on page 596, while Fig. 8, on page 597, shows the platform above the retorts and the hoppers mentioned above. The appearance of the front of the retorts and of the front of the cooling chambers whence the coalite is withdrawn, are illustrated respectively in Fig. 39, Plate XXXVII, and Fig. 6, Plate XXXVI. These views should be referred to in connection with Figs. 9, 10 and 11, on page 597, which give sections through the retort-house and make clear the arrangement of the various portions shown in the half-tone engravings. Underneath the roof the coal conveyor shown will eventually run. Beneath it are the measuring hoppers, and directly beneath each hopper is the corresponding retort. Rotary valves, operated from the gallery, admit the charge to the retorts. At each end of the latter are the burners and regenerator passages, occupying altogether the full width of the house. At the bottom of each retort is a dumping door, which when opened allows the carbonised charge to fall into the narrow water-jacketted cooling chamber beneath. The front of each chamber is closed by an airtight door, through which the coalite, when cool, is drawn out on to the sloping platform running along the front of the bench. The gas given off from the charge leaves each retort through a branch connected to the back end of the retort top, and passes into the hydraulic main through swan-necks in a manner similar to ordinary gas-works practice.

The construction of the retorts is shown in Figs. 12, 13 and 14, annexed. They are built up of firebrick, each retort having a total depth of 9 ft. 6 in.; a length, tapering from top to bottom, of 7 ft. 3 in. to 7 ft. 6 in., and a width of 11 in. They are arranged at a distance, centre to centre, of 21 in. The interiors have semicircular ends, as shown in Fig. 14. Inside each retort is a pair of collapsible iron plates which will be referred to later. These occupy the central portion of the space, and the charge lies between them and the walls in two layers of about 3½ in. in thickness. This arrangement not only permits the free escape of the gases, which pass through perforations in the plate and rise without hindrance through the comparatively cool space between the plates, but the collapsing of the latter completely frees the carbonised charge and causes it to fall from the retort without any necessity for poking.

Each retort stands on a cast-iron casing containing a rocking cylindrical valve upon which the charge normally rests. The details of one of these valves are shown in Figs. 40 and 41, Plate XXXVII. The valves are operated by external levers, which have to pass each other on account of the proximity of the retorts. To provide for this the levers are arranged

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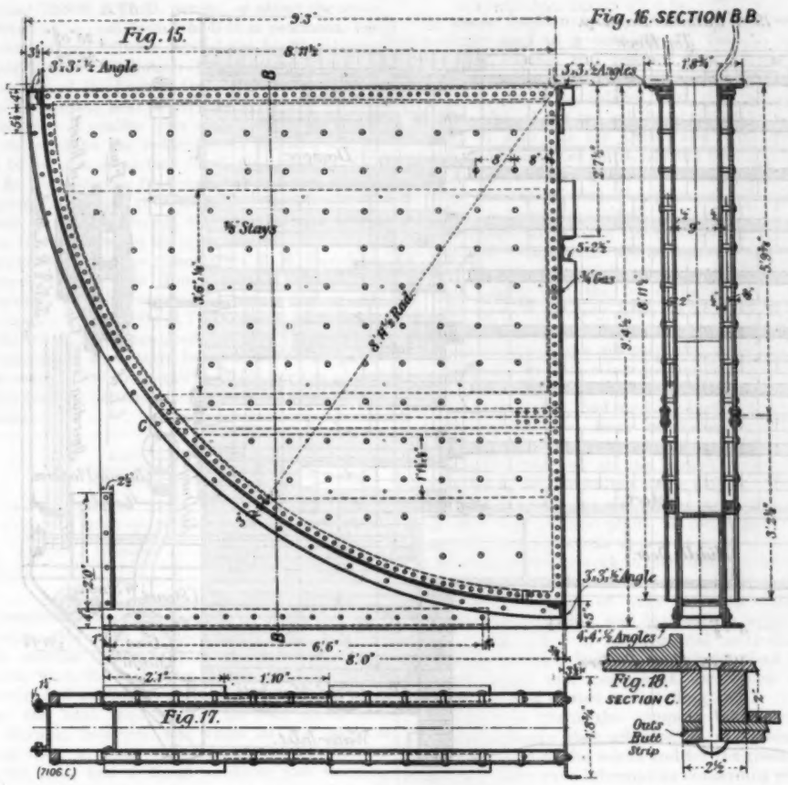

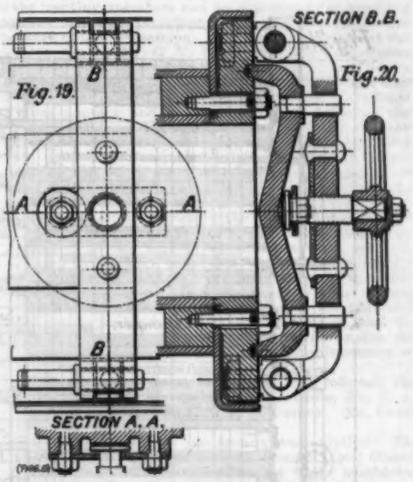

in groups of four at successively greater distances from the retort bench, so that any one when moved through the full extent of its travel will clear the other three, which otherwise would foul it. The arrangement will be readily understood from Figs. 40 and 41. The door spindle is formed of tubing which communicates with a post running through the metal of the door. There is an arrangement for feeding water slowly into the interior of the spindle, where it is evaporated, the steam escaping through holes in the door plate. An external overflow device prevents the water rising to the level of the door, so that only steam can escape. The action of the steam on the charge undergoing carbonisation results in an increase of the ammonia in the gas given off.

The opening of one of the valves dumps the charge into the cooling chamber below, the cast-iron plates above mentioned having been collapsed. A cooling chamber is illustrated in detail in Figs. 15 to 18, annexed. It is made of sheet steel, the two water-jacketted sides being connected by a curved steel back. Thin vertical plates are fixed centrally between the sides of the water-jackets so as to separate the water into two sheets. The water nearest the interior of the chamber will rise as it becomes heated by the hot charge and will be replaced by cooler water flowing down the outer space, so that a continuous circulation will be kept up. Practically the whole of the heat of the red-hot charge of coalite is thus absorbed, the temperature of the material being reduced sufficiently for it to be able to be held in the hand before it ever comes into contact with the external air. Not only is the sensible heat usefully recovered by these cooling chambers, but the value of the coalite is unimpaired either by combustion or by the application of water. The steam generated in the cooling chambers is to be used for fractionating the tar oils, as soon as this can be undertaken at the works. The coalite can be sufficiently cooled in two hours, but it is left in the chambers until the time approaches for dropping the next charge.

When the coalite is to be withdrawn, the vertical door which closes the front of the chamber is opened, and the material is raked out, the sloping back of the chamber facilitating this operation. The doors of the cooling chambers are well shown in Fig. 6, Plate XXXVI, and details of the mechanism by which they are operated are given in Figs. 19 and 20, annexed. The joint is made air- and gas-tight by a sharp edge on the cover which is forced into asbestos packing contained in a groove around the face of the door-frame. To open the door the hand wheel is given half a turn or so, which relieves the pressure of the screw. The pin at either end of the cross strap is then withdrawn and the door can be swung open, the pin at the other end acting as a hinge.

Sections through the retort settings are given in Figs. 21 to 24, on page 600. The retorts are heated by gas, either originally generated within them or supplied from some outside source. At Barugh the retort gas is used at present, being returned to the bench for this purpose after being cooled and washed to extract the tar and ammoniacal contents. A Mond gas producer is also available for the supply of heating gas. The gas is brought from the gasholder to mains which run horizontally along the bench on both sides. From these vertical risers ascend and supply small horizontal pipes which enter the settings, as shown in Fig. 21, page 600, and Fig. 39, Plate XXXVI. One side of a retort is heated from one main and the other side from the other main. From Fig. 21 it will be seen that the heated gas from the upper burner on the right-hand side passes horizontally across the side of the retort, then down through a damper into the next horizontal passage, and so on in a zigzag path through all the passages until it reaches the bottom when it enters the regenerator passages. The positions of the various dampers at the ends of the passages are controlled by means of the small doors on the faces of the setting. In the illustration some of the dampers are shown completely shutting off their respective passages, a condition which of course would not obtain in practice. The flame from the second burner from the top meets the hot gases from the first burner in their third pass, and the flame from the third burner meets the combined flow in the fifth pass, and so on. The arrangement is said to work quite satisfactorily.

We have already referred to the collapsible plates which are situated inside each retort, and explained their function, namely, to permit the ready escape of the gases from the coal, and especially to cause the carbonised charge to fall freely into the cooling chamber when the dumping door is opened. To these plates is attributed much of the success of the installation, for the jamming of the charge in the retorts has formerly been one of the greatest difficulties which those who attempted low temperature carbonisation have had to contend with. Furthermore, the passage of the gases through a dense mass of heated coal which had to take place in the older styles of retorts altered their constitution and depreciated their quality. The collapsible plates used by Messrs. Low Temperature Carbonisation, Limited, are of manganese cast-iron which is extremely hard and stands the somewhat arduous service without suffering undue growth or other trouble. The way they are arranged in the retorts is shown in Figs. 25 to 27 on Plate XXXV, while Figs. 28 to 37 on Plates XXXV and XXXVII, illustrate the details of the plates and of their fittings. The plates are hung from a bridge-piece shown in Fig. 25, which can be partially rotated when desired by means of the wrench shown in Fig. 36. This wrench is inserted through a manhole on the top of the retort and engages with the castellated collar, Fig. 34, which is keyed to the end of the bridge-spindle. The latter is carried in cast-iron bearings (Fig. 35) which merely rest in position, so that if necessary the whole of the ironwork, bridge piece, plates and bearings can be withdrawn together from the top of the retort.

Each plate, for convenience of manufacture, is made of three parts, as shown in Figs. 28 to 31, these being afterwards bolted together to make one complete plate 9 ft. 6 in. long and 6 ft. 5 in. wide. Normally the tops of the two plates are at the same level and the bridge piece shields the space between them, so that when the retort is charged the coal is deflected by the bridge and separated into two streams which fill the spaces between the outside of the plates and the side walls of the retort. The plates are kept apart by flange abutments which prevent them being forced together by the pressure of the coal so long as the plates are level with each other. At the lowest of these pairs of abutments the plates are connected by links which prevent the plates being separated by more than a predetermined amount. The arrangement of the abutments and links will be understood from Figs. 25 and 37 taken in connection with the other views. The

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Fig. 21.

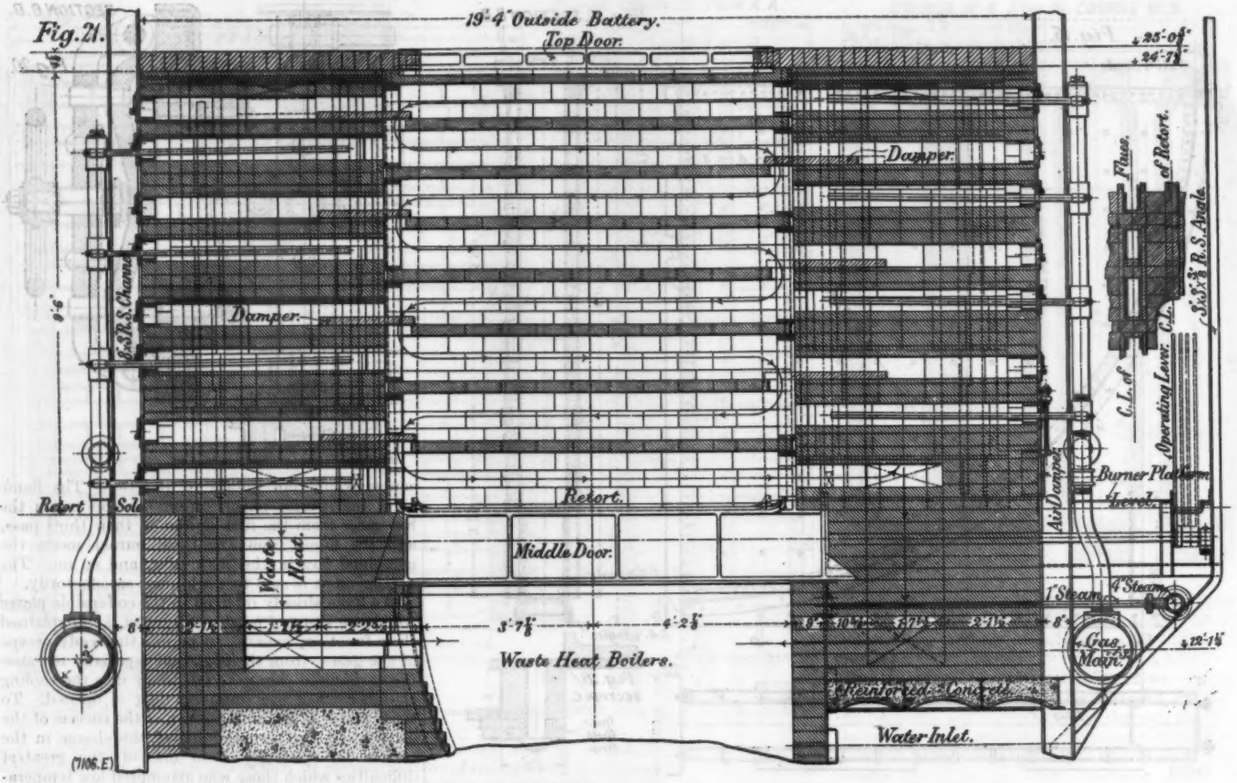


Fig. 22. SECTION THRO' WASTE HEAT FLUES.

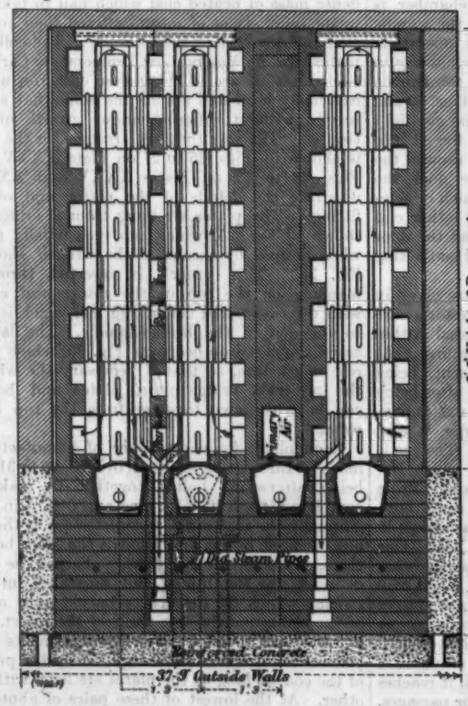


Fig. 23. SECTION THRO' PRIMARY AIR FLUES. SHOWING ALTERNATE NORMAL WORK.

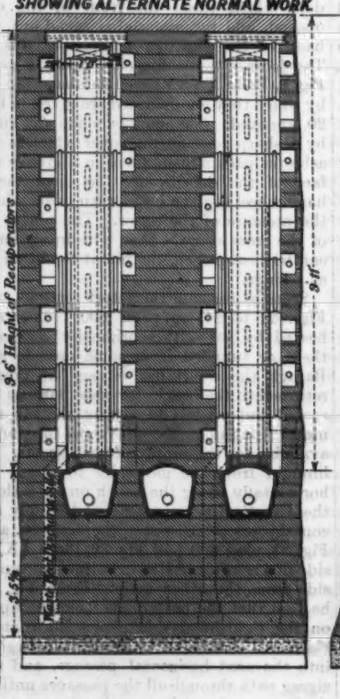
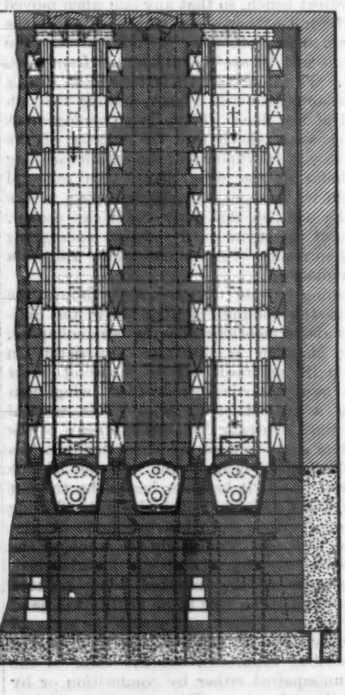


Fig. 24. SECTION THRO' SECONDARY AIR FLUES.



illustrations just mentioned show what happens when the bridge piece is rocked over to one side by the spanner, as is done when it is desired to discharge the retort. One plate rises slightly and the other falls by an equal amount, the pin joints at the top and bottom causing the plates to come together. The abutments slide past each other to permit of this, as shown in Fig. 37. The consequence is that the plates which occupied a space 5 in. wide when open only occupy a space of 3 in. when collapsed, so that the charge is completely freed and can fall instantly when the dumping door is opened.

There is no need to describe the washery, coal handling plant, sulphate plant, &c., at Barugh, as these follow along the lines of modern practice,

and the interest of the installation centres in the retort house with which we have fully dealt. As regards the coalite produced, we have already given a typical analysis of it and described its physical characteristics. It has a calorific value of about 13,500 B.Th.U. per lb., or about the same as that of the coal from which it is produced, but is lower in ash. Tests carried out by Manchester Corporation Air Pollution Board show that the percentage of the heat of the fuel given out in the form of radiant heat is very substantially greater in the case of coalite than coal, a result no doubt due in point to the nature of its surface, and in part to its greater surface for a given weight. As it is for domestic use that coalite is expected to find its greatest market, this point is of importance, for almost everything except the radiant heat is lost when fuel is burnt in an open grate.

According to figures given by Mr. T. M. Davidson, engineer to the Low Temperature Carbonisation Company, the heat required to turn a ton of coal into coalite is 2,500,000 B.Th.U., as compared with 3,000,000 B.Th.U. required for high temperature carbonisation, the retorts being heated with gas in both cases. The comparative yields per ton of coal carbonised by various processes are stated to be as follows :—

—	High-Temperature Gas Works.	High-Temperature Coke Oven.	Low Temperature.
Gas	12,000 cub. ft. (550 B.Th.U.)	11,500 cub. ft. (450)	6,000 cub. ft. (700)
Tar	10 gallons	8 gallons	20 gallons
Coke	13·5 cwt.	14·4 cwt.	14·0 cwt.
Sulphate ..	25 lb.	28 lb.	15 lb.

Considering first the gas produced when coalite is made, this is, as has been mentioned, of a very high calorific value. From the table it would appear that the gas from 1 ton of coal would contain 4·2 million B.Th.U., or 68 per cent. more than the heat required for its own production. At Barugh, however, the whole of the gas was being used to heat the retorts on the occasion of our visit, and a Mond producer was standing by in readiness to make up any deficiency. It is possible that if operations were conducted on a larger scale, and a hundred or more retorts were in service, the gas consumed per ton of coal carbonised might be reduced so that a surplus would be available for sale, but there appeared no reason to suppose that any such surplus would be of much importance. It is quite practicable, of course, to make a low-grade producer-gas for retort heating, and to sell the whole of the high-grade gas to gas companies, but unless a B.Th.U. contained in high-grade gas has a greater market value than the same quantity of heat in poor gas, there is nothing to be gained by the substitution, which would moreover entail extra labour and expenditure on plant. The Barugh plant may be working at a certain disadvantage due to the fact that the retorts, originally designed to hold 15 cwt. of coal, are only dealing with 12 cwt. per charge, for reasons already mentioned. The same number of burners as would be used for the designed charge are in use, and this may lead to reduced economy. But as the retort temperature is no higher than it should be, it would appear that the heat is effectively used and is therefore necessary. The gas leaving the retorts is at a temperature of only 70 deg. C., so that no appreciable amount of heat is carried away by it.

The tar resulting from the distillation resembles crude oil in appearance, and is very different from the tar produced by high temperature carbonisation. It has a specific gravity of 1·06 at 15 deg. C. as compared with 1·18 for ordinary gas works tar, while its free carbon content is generally less than 1 per cent. as compared with over 6 per cent. in the case of ordinary tar. It contains no naphthalene and much less pitch than ordinary tar; the residue at 300 deg. C. is about 43 per cent., and from this a heavy lubricant resembling vaseline can be extracted by treating it with steam. The final pitch residue is 34 per cent. The nature of the tar is indicated to a certain extent by the figures given in the next column which show the fractions at various temperatures.

Temperature C.	Fraction.
170	4·5
210	15·3
240	14·2
300	23·0
Pitch	43·0
	100·0

The whole fraction up to 300 deg. C. has been successfully used in a cold-starting Ruston and Hornsby oil engine, and resulted in a consumption of 0·49 lbs. per b.h.p. at the most economical load. It is considered that the greatest probable value of the tar will be obtained by fractionating it into oils for Diesel and semi-Diesel engines, and into motor spirit, as from 5 to 7 gallons of the former and two gallons of the latter can be obtained per ton of coal, the pitch residue being dealt with as above mentioned.

The commercial value of the processes developed by the Low Temperature Carbonisation Company will depend, of course, chiefly upon the prices obtainable for coalite and the by-products. The raw material used is of very little value, indeed the non-coking slack which forms the greater part of it has in normal times scarcely any value at all, and is left in the pits when loading is done with forks. The technical problems of turning such raw material into useful fuel and by-products would appear now to have been satisfactorily solved. The labour cost moreover should not be great, for the staff employed at the Barugh works only number about 24, excluding those engaged in the offices, and this number will be proportionally less when the size of the plant is increased. The organisation of the works appeared to be efficient, and all constructional work to have been thoroughly well carried out. The retort house, in particular, is a very good piece of work both as regards design and construction, and has nothing whatever about it suggestive of experimental methods or makeshift devices. Indeed, the whole plant has the substantial and permanent air which one associates with a settled undertaking.

We have to thank the company both for the recent opportunity they afforded us of making a full examination of the works and for the readiness with which they gave information concerning every detail of the plant and of processes employed. We may add that the London offices of Messrs. Low Temperature Carbonisation, Limited, are at 14 and 16, Cockspur-street, London, S.W. 1.

IRON AND STEEL INDUSTRY IN INDIA.—We are informed of the recent registration in India of "the United Steel Corporation of Asia, Limited," with a capital of 20 crores of rupees, by Messrs. Bird and Co., Calcutta, and Messrs. Cammell Laird and Co., Sheffield and London. It is proposed to establish as soon as possible works on a large scale near the deposits of iron, coal and limestone in India. Messrs. Bird control a large number of Indian collieries, extensive iron ore deposits and limestone areas. Messrs. Cammell Laird are acting as technical advisers to the corporation and are responsible for the design, erection and staffing of the works. The plant to be put down is designed to produce ultimately, per year, 600,000 tons to 700,000 tons of pig-iron, and 450,000 tons of finished steel. At first, however, the production of half the above quantities is contemplated.

THE LATE MR. WILLIAM DENTON.—We regret to have to announce the death, which occurred suddenly last Saturday, the 22nd inst., at his residence, River Bank, Alnmouth, Northumberland, of Mr. William Denton, a director of Messrs. Swan, Hunter and Wigham Richardson, Limited, of the Wallsend Slipway and Engineering Company, Limited. Mr. Denton served his apprenticeship at a shipyard on the Wear, together with Sir G. B. Hunter, the chairman of Messrs. Swan, Hunter and Wigham Richardson, and at the end of his term he established in business at Cardiff as a shipbroker. He then entered the commercial department of Palmers' Shipbuilding and Iron Company, Limited, Jarrow-on-Tyne, serving under his uncle, the late Mr. John Price, who at that time was the general manager. When Messrs. C. S. Swan and Hunter became a limited liability company, about twenty-five years ago, Mr. Denton left the Jarrow firm and joined the Wallsend one as a director. Mr. Denton's energies were devoted to the design and construction of floating docks, a branch of the shipbuilding industry which he carried to a most successful issue. Mr. Denton was 72 years of age, and had for the last few months practically retired from active business, although he continued to take full interest in the work of the concerns of which he was a director. He became a member of the Institution of Naval Architects in 1875; he was also a member of the North-East Coast Institution of Engineers. Mr. Denton was widely known in all shipping circles throughout the country, and was held in high esteem by both his co-directors and the men employed by the companies in which he was interested.

THE SOCIETY OF GLASS TECHNOLOGY.

THE opening meeting of the session 1921–22 was held in the Applied Science Department, the University, Sheffield, on Wednesday, October 19, 1921; the president, Dr. M. W. Travers, F.R.S., in the chair. Prior to the meeting, members had an opportunity of lunching together, when the president made some observations on the work of the new session. The first paper given at the meeting was by Mr. G. V. Eyers on "*The Comparative Compositions of Pot Clays from the Stourbridge District During the last Fifty Years.*" It was found that the clay of the present day showed a decrease in the percentage of silica content and a corresponding increase in the alumina content. Its refractoriness was in no way inferior to that of clays obtainable thirty and fifty years ago. Therefore, the complaint of glass manufacturers and other users of refractory materials that the refractories of to-day are inferior to those of yesterday would hardly be substantiated. In the lecturer's opinion the greatest failure in pots of the present time was due not to the inferior quality of the refractory materials, but rather to the higher temperatures used, and the increased production, involving increased duty on the pot. If the refractory manufacturer was to make improvement in the quality of his material he needed the active co-operation of the users of his material, and he made a plea for systematic information from the users of refractory materials, which would enable the producers to modify or improve their refractories to suit particular requirements.

There took part in the discussion that followed the president, Mr. W. J. Rees, Dr. C. J. Peddle, Mr. E. A. Coad-Pryor and Professor W. E. S. Turner. Mr. Eyers replied.

The second paper on the agenda was entitled "*The Properties of the Lime-Magnesia (Dolomite Lime) Glasses and their Commercial Application,*" by Violet Dimbleby, B.Sc., S.English, M.Sc., F. W. Hodkin, B.Sc., and Professor W. E. S. Turner. This paper was given by Professor Turner and illustrated by lantern slides. Professor Turner said that the introduction of small amounts of magnesia together with lime resulted in the production of a more fluid glass, which was much more easily melted than the corresponding magnesia or lime glasses. The lowering of the annealing temperature due to the use of both the ingredients, and the reduction as compared with the lime containing glass of the thermal expansion, rendered annealing easier, and would reduce the amount of fuel required for the lehrs. The production of such glasses depended on a supply of a suitable form of magnesia or dolomite limestone. Up to the present no source of such material was known where the iron content was sufficiently low to permit the manufacture of colourless glass from it, and an appeal was made for any possible information as to a likely source for obtaining such material with an iron content of something like 0·1 per cent. In discussion, Mr. W. J. Rees, B.Sc., F.I.C., mentioned that he had examined the majority of magnesites and magnesian limestones obtainable in this country and elsewhere, and was unable to suggest a suitable source. The Greek magnesites were exceptionally pure, but their utilisation in the glass industry was almost certainly prohibited by the cost as compared with the British limestones.

There also took part in the discussion the president, Messrs. V. H. Stott and E. A. Coad-Pryor, Professor W. E. S. Turner and Mr. F. W. Hodkin replied. The president intimated that the next meeting would be held in Leeds on November 16. This meeting would resolve itself into a discussion of questions sent in by members on matters relating to the melting of glass.

"NAPIER'S BONES."—Under the title of "Wee" Calculating Slips, Messrs. Bowman and Murdoch, of 99, Shoe-lane, London, are issuing, at the price of 1s. net a set of "Napier's Bones," printed on cardboard and mounted on wood. The publishers, in sending us a specimen, make no mention of the fact that these "bones" were invented by Napier of Murchestown, the discoverer of logarithms, who died in 1617. At one time they were fairly extensively used owing to the circumstance that children were not taught the multiplication table. In fact, Pepys records in his diary that he himself did not master the multiplication table till some twenty-seven years of age. Once improved methods of teaching arithmetic came into vogue the popularity of Napier's Bones declined, and by the middle of the nineteenth century few people were acquainted with them. It is probably the consideration of the above facts that makes the publishers lay stress on the educational value of the "Bones," rather than on their practical utility.

AUSTRALIAN RAILWAY REQUIREMENTS.—The Victorian Government Railway Commissioners invite tenders for the supply and delivery of:—(1) Double-headed screwing machines and forging machines for Newport Workshops (Contract No. 34,648); (2) 60 tons galvanised telegraph wires as specified (Contract No. 34,706); (3) 23 steam meters and accessories for Newport Power House (Contract No. 34,611); (4) 150 electric train stops for power signalling (Contract No. 33,546). Sealed tenders on proper forms, and accompanied by a preliminary deposit of ½ per cent. of the total amount of the tender, will be received by the Victorian Government Railway Commissioners, Melbourne, up to December 14 in the case of No. 1 and up to January 4 in the cases of Nos. 2, 3 and 4. Local representation is essential. Copies of the specification and conditions may be consulted by United Kingdom firms interested on application to the Enquiry Room, Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1. Reference No. 6,968/ED/PN.

INDUSTRIAL NOTES.

The proposals of the Government for dealing with unemployment were put before the House of Commons last week by the Prime Minister. They are, briefly, as follow :—

A grant of 300,000*l.* to facilitate the emigration to the Dominions of ex-service men.

The export credit scheme to be extended. The guarantee to traders to be raised from 85 per cent. to 100 per cent., and the scheme to include the British Dominions.

The extension of credit for engineering contracts.

Development of the resources of the British overseas areas.

The Government to assist in the raising of capital for essential enterprises which would promote employment, guaranteeing the payment of interest and loans up to a sum not to exceed 25,000,000*l.*

A sum of 10,000,000*l.* to be allocated for assisting relief works in forestry and land drainage.

A compulsory weekly levy in insured trades (for men : employer 2*d.* ; employed 2*d.* ; State 3*d.* ; for women, boys and girls : employer 1*d.* ; employed 1*d.* ; State 2*d.*), for establishing a fund from which to make grants to the dependents of insured unemployed. The grants to be at the rate of 5*s.* per week for the wife and 1*s.* per week for each child, the maximum limit per week being 9*s.* This fund, to be called "The Unemployed Workers' Dependents' Fund," forms the subject of a Bill discussed in Committee during the week. It is to last for a period of six months.

Government loans to the Board of Guardians in necessitous districts.

These proposals can hardly be considered in the light of a cure for unemployment, although the first one—facilities granted to ex-service men for their emigration to the Dominions—may have much in its favour ; unfortunately, matters in the Dominions do not appear to be much brighter than here. We refer our readers to the remarks on the situation recently made by Lord Weir and contained in a note in our last issue, and may add that if our manufacturers and traders cannot sell our British products owing to the high cost of their production no credit scheme can be of any assistance. The Parliamentary Labour Party is opposing the second reading of the Bill on the Unemployed Workers' Dependents' Fund as it stands, and are asking for a greater relief.

The present economic situation of the country was reviewed last week end by Sir Hugh Bell, Bart., when speaking before the Northern Liberal Federation. There was, he said, only one remedy, easy to state but difficult to adopt, namely, thrift and industry. Lately, we had greatly shortened the hours of labour. He had never believed in the 12-hour day. He was prepared to believe that 8 hours was as long as a man ought to work, but in that time the fullest energy ought to be put forward to secure the greatest possible product. If a man did not give his best he was robbing his employer and the community, and until he could be convinced that he was anti-social, the remedy was far to seek. The great remedy for the present situation was to enlarge total output as much as possible.

Speaking at the same time at a meeting in the Victoria Hall, Sheffield, in support of the Middle Classes Union, Lord Askwith said that relief work was not of much value because it only handicapped a skilled workman afterwards in the trade in which he had been brought up. They could not go on finding 10,000,000*l.* after 10,000,000*l.* for the relief of distress. They wanted those who were distressed to be at work and to assist in the production of the nation, and to assist themselves and their families. That could not be done unless the people would work when they got work. It was absolutely necessary by some means to reduce the margin of difference between the cost at which we were now producing our goods and the cost at which our competitors were selling theirs in the markets of the world. We had a hard task before us, and it could not be accomplished if we had internal fighting. In the matter of Labour Exchanges, to which he referred, Lord Askwith said he did not think much of them, and preferred to see employers and employees dealing with their own industries.

The quarterly meeting of the Associated Chambers of Commerce was held at the Cutler's Hall, Sheffield, last Friday, when, among the resolutions passed was the following one, moved on behalf of the Executive Council by Mr. Stanley Machin, president of the London Chamber of Commerce :—

"That while steps should at once be taken to organise relief in the provision of works of public utility, the problem of unemployment can only be permanently settled by reduction in the cost of production and by the development of overseas trade. The association welcomes the simplified scheme of export credits announced by the Government, and hopes that foreign trade may thereby be extended. While the disorganisation in foreign markets in consequence of the war is fully recognised, the abnormal increase in the cost of production, especially in regard to coal, has rendered competition abroad exceedingly difficult in most trades, and such abnormal increase is amongst the chief causes of the present stagnation in industry—a condition of affairs which has been greatly aggravated by frequent strikes and labour disputes which have destroyed confidence upon which enterprise and industry depend. The Association is further of the opinion that it is only by full co-operation between Capital and Labour that the industries of the country can be developed and a full measure of employment secured. The employers are ready for such co-operation."

Another, and most important resolution passed at the same meeting was one urging the Government to introduce legislation to insure that, whenever a ballot or referendum is used by either employers or employed, the voting shall be under the same system of secrecy as that employed at Parliamentary and municipal elections.

Messrs. Swan, Hunter and Wigham Richardson, Limited, have issued the following comparative figures of costs and work done in the case of three sister ships built at different periods in their yards :—

Franconia : Date of trial, January 21, 1911. Cost per ton of steel, 3·58*l.* Weight of steel worked per ironworker per week, 9·91 cwt.

Laconia : Date of trial, December 8, 1911. Cost per ton of steel, 3·875*l.* Weight of steel worked per ironworker per week, 9·52 cwt.

Laconia : Launched, April 9, 1921 (ten years later, and now almost completed). Cost per ton of steel, 11·73*l.* up to August 16, 1921, which will be further increased a little. Weight of steel worked per ironworker per week, 7·35 cwt.

The nominal wages advance was 142½ per cent. this was the advance as agreed between the workmen and the employers. The actual advance, however, was 228 per cent. It was expected that with a reduction of working hours no less work would be done ; the above figures, however, show that practically 26 per cent. less work per week is being turned out in 1921 than in 1911.

Statistics compiled by the Ministry of Labour show that the total number of registered and unregistered trade unions at the end of 1920 was 1,391, having a total membership of about 8,502,000, as compared with 8,051,000 at the end of 1919, showing an increase of 5·6 per cent. The total number of male members was about 7,139,000. The total of 8,502,000 includes about 72,000 members of oversea branches of certain unions, and also a number of persons, principally teachers, who are members of more than one society, and are therefore counted twice. Making the necessary allowance for these cases, the net number of members in the United Kingdom would appear to be not more than 8,400,000. The following are figures for several groups of unions :—

—	Unions.	Men.	Women.	Total.
Mining and Quarrying :				
Coal-mining	101	1,105,739	8,062	1,113,801
Other mining and quarrying	10	38,433	—	38,433
Metal, Engineering and Shipbuilding :				
Iron and steel manufacture	11	162,374	1,636	164,010
Ironfounding, engineering and shipbuilding	65	887,049	1,221	888,270
Other	62	78,552	14,599	93,151
Transport :				
Railway	10	605,685	12,325	618,010
Tramways and Road Transport ..	14	215,932	60	215,992
Seafaring	16	177,048	240	177,288
Dock, Canal and Riverside	26	110,526	1,128	111,654
General Labour ..	16	1,320,209	221,838	1,542,047

Mr. Ben. H. Morgan, chairman of the British Empire Producers' Organisation, presided over a meeting of the council held on Wednesday, the 19th inst., at which he gave an account of his recent tour throughout Canada on behalf of the organisation. In the course of the meeting, the following resolution was passed unanimously :—

"This organisation strongly approves the proposal of the Right Hon. Winston Churchill, Secretary of State for the Colonies, that monetary credits be extended by the British Government to the Crown Colonies to enable approved development schemes in those territories to be carried out, and that all orders in connection with such schemes should be placed with British manufacturers ; and is of the opinion that the result of immediate action in this direction will be to stimulate trade within the Empire and sensibly to diminish unemployment in this country. It is further the opinion of this organisation that some guarantee of the continuity of such development and of the consequent placing of Colonial orders with British firms is advisable, on the ground that it would have an immediate effect in the restoration of confidence and the encouragement of industrial enterprise."

In connection with the necessity of stimulating inter-Empire trade and giving it security, a resolution asking for the confirmation of the reciprocal trading arrangements with the West Indies was also passed in the following terms :—

"This organisation is of the opinion that trade between the United Kingdom and the West Indian Colonies would be increased and the economic ties strengthened by the confirmation, for a period of ten years, of mutual preference in duties."

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—While an encouraging increase is shown in the number of inquiries, the volume of business actually booked leaves much to be desired. In the market for raw and semi-finished materials, successive price reductions have resulted in quotations in some cases reaching the level of those circulated by Continental producers. But even with the added attraction of guaranteed quality, consumers are not inclined to commit themselves far ahead. The possibility of a further adjustment in values is also a factor of influence in causing them to restrict current purchases. The latest prices officially circulated in South Yorkshire are as follow :—Siemens acid billets, 14*l.* ; Bessemer acid billets, 13*l.* 10*s.* ; soft basic billets, 7*l.* 15*s.* to 9*l.* ; crown bars, 14*l.* 10*s.* ; iron hoops, 17*l.* 10*s.* ; steel hoops, 14*l.* 5*s.* ; mixed hematites, 6*l.* 15*s.* ; Derbyshire foundry iron, 6*l.* ; Derbyshire forge, 5*l.* 15*s.* Following the advent of cheaper coke and in consequence of the abundance of Swedish pig-iron and alloys now available, high-speed steel has eased 4*d.* to 6*d.* per pound. Steel with a content of 18 per cent. tungsten has been marked down to 3*s.* 3*d.* per pound, and steel containing 14 per cent. tungsten, to 2*s.* 8*d.* per pound. Rumours are in circulation respecting the new British Admiralty contracts, and confirmation is forthcoming in the case of Messrs. John Brown and Co., Limited, who report that an order to build one of the four battle cruisers required has been placed with them. When work will be commenced depends upon the receipt of drawings. A fair amount of activity prevails in the wagon building and locomotive section, but departments devoted solely to the production of springs and axles find difficulty in maintaining full-time operations, despite the fact that prices have declined 20 per cent. during the last nine months. No improvement is reported in open-hearth furnace production. The crucible furnaces are producing only a minimum of high-speed steel, owing to the further unloading of stocks at cheap rates.

South Yorkshire Coal Trade.—Further weakness in best steam hards is accounted for by the fact that railway companies have acquired considerable stocks and are taking lighter deliveries. The manufacturing demand is much below the capacity for output. Steel-makers and engineering masters are pressing for further reductions in contract prices. General weakness is reported in the market for cobbles and nuts. Smalls are being disposed of at a wide variation of rates to free collieries from congestion. All classes of coke are going away slowly except foundry sorts. Quotations unchanged.

The Brewers' Exhibition.—The thirty-eighth annual exhibition and market of the brewing and allied trades will be opened to-morrow at the Royal Agricultural Hall, Islington, N., and will remain open until Friday, November 4. As usual, machinery and appliances will form an important feature of the exhibits so that engineers should find plenty of material to interest them.

The Transvaal Coal Trade.—We read in *The South African Mining and Engineering Journal* that the falling-off in the export and bunkering trade at Delagoa Bay and accumulation of stocks resulted in restriction of the Transvaal output during June, but recent shipments have relieved the congestion and some improvement is expected. The following are the output figures in the Middelburg district for the month of June : Number of collieries producing, 20 ; tons of coal mined, 492,560 ; tons of coal sold, 415,438 ; total value realised, 137,235*l.* ; value per ton at pit's mouth, 6*s.* 7·28*d.*

Personal.—Messrs. Ed. Bennis and Co., Limited, Publicity Department, 28, Victoria-street, Westminster, London, S.W. 1, state that they have a large number of lantern slides available for lecture purposes. The slides cover the whole field of development in connection with mechanical stokers, and coal and ash-elevating and conveying plant. A booklet giving titles and a brief description of the slides will be sent to any inquirers on receipt of a request.—Messrs. Jones and Shipman, Limited, Leicester, have recently opened a new extension in East Park-road, built to accommodate a comprehensive stock of machine tools. Whilst the bulk of machines on show are drilling and grinding machines, there are also new and second-hand special bargains in lathes, milling machines, automatics and shaping machines, particulars of which can be had on application to the chief offices at New Century Works, Leicester.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is very quiet. The quantity of No. 3 G.M.B. available for disposal is very limited, but appears to be ample for present small requirements. Market quotations for the ruling quality remain at 120*s.* for home use, and 125*s.* for shipment to foreign destinations. There is very little No. 1 to be had, and the price of it is put at 5*s.* above No. 3. Foundry 4 is less plentiful, and the pressure to sell that quality is not so pronounced as it has been. The quotation is 119*s.* No. 4 forge still stands at 112*s.* 6*d.* Mottled and white iron are plentiful and difficult to dispose of at 110*s.*

Hematite.—There is possibility of curtailment of production of East Coast hematite, as supply is a good deal in excess of requirements, and values show a rather marked downward tendency. Producers are keen to book orders, and are prepared to make price concessions, particularly for foreign business. Both for home consumption, and for export, Nos. 1, 2 and 3 are 120*s.* to 125*s.* Mixed Nos. are thus of the same value as No. 3 Cleveland, whereas in normal times they used to be 8*s.* to 10*s.* above the ruling quality of Cleveland pig-iron.

Foreign Ore.—No new feature is noticeable so far as foreign ore is concerned. Consumers continue to carry considerable stocks, and have large undelivered supplies to take up against old contracts, so that they are not in the market to buy. Transactions are confined to sales of odd cargoes.

Coke.—Coke is easier, but sellers still ask more than local users are prepared to pay. Durham blast-furnace kind is quoted up to 32*s.* 6*d.* delivered, but customers consider that 30*s.* should be the outside quotation, and there are indications that business might be put through at the latter figure.

Manufactured Iron and Steel.—Sales of the various descriptions of manufactured iron and steel are still slow, but inquiry for some materials shows slight improvement. Among the principal market quotations are: Common iron bars, 14*l.*; steel billets, 10*l.* 10*s.* to 11*l.*; steel ship, bridge and tank plates, 10*l.* 10*s.*; steel angles, 10*l.*; steel boiler plates, 10*l.*; steel joists, 10*l.* 10*s.*; heavy steel rails, 10*l.* 10*s.*; fish plates, 15*l.* 10*s.*; black sheets, 15*l.* 10*s.* to 16*l.*; and corrugated galvanised sheets, 19*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The position of the steel industry of Scotland has not changed for the better, and the depressed state of the past few months continues. The reductions made in prices last week have not brought out much fresh business, but inquiries are better. The latter, however, have been rather more numerous in recent times and in a number of cases are only for testing the market and little business results. There are many buyers quite anxious to come into the market, but even yet they do not consider that the most opportune moment has arrived, with prices falling periodically. When the Scottish steel-makers reduced their quotations last week the English makers made a bigger cut in plates and sections on account of special local circumstances, and because of this many buyers are under the impression that a further fall in the Scottish prices is imminent in the near future, hence their unwillingness to give out orders at present. The news that the Clyde is to receive a large portion of the Admiralty's order for warships has given a great amount of satisfaction in business circles, and a more hopeful outlook is now general. The present demand from shipbuilders is almost at vanishing point, and it is generally known that the various steel works are working without profit at the present time on account of the prevalent high cost of fuel and raw material. Black sheet makers have very little business on hand, but foreign inquiries are improving and a slightly better feeling is general. Export all round is very poor indeed, despite the fact that makers are free to quote their own figures and are giving exceptionally low quotations.

Malleable Iron Trade.—There is very little doing at the various malleable iron works in the West of Scotland and the demand is so small that it is well nigh impossible to secure anything approximating a full week. Consumers complain that the price of 14*l.* for "crown" bars is much too high and that it is keeping back business, but while producers are as anxious as possible to name a lower figure they are up against very heavy oncost charges. Everything is showing a tendency to come down to lower levels and a further reduction in bar iron is highly probable at no very distant date.

Scottish Pig-Iron Trade.—Practically no change of any kind has taken place in the pig-iron trade of Scotland during the past week, and the output of the different furnaces is more than equal to to-day's demands. Home consumers of both foundry iron and hematite iron are not in a position to take up large quantities at the present time owing to the industrial depression, and foreign customers are also doing very little in the way of buying. With wages and fuel both easier the prices of pig-iron have fallen a little and the following may be taken as to-day's quotations:—Scotch hematite, 7*l.* 5*s.* per ton, delivered steel works; foundry iron, No. 1, 7*l.* 5*s.* per ton, and No. 3, 7*l.* per ton, both loaded in trucks at makers' works.

Shipbuilding.—The shipbuilding industry of Scotland has been passing through very dull times of late and new contracts have been almost impossible to secure. The result is that a great amount of unemployment exists at the present time in the different areas and particularly so on the Clyde. Renowned for warship work, it is most gratifying that the Admiralty tenders have resulted in a very good proportion of the new work being placed with Clyde firms. Official information is that Messrs. John Brown and Co., Clydebank, and Messrs. The Fairfield Shipbuilding and Engineering Company, Limited, Govan, are each to build one battle-cruiser, both hull and machinery. One is also to be constructed on the Tyne and keen speculation is now going on as to which yard is to secure the order for the fourth vessel. It is now stated that Messrs. William Beardmore and Co., Limited, Dalmuir, are to receive the contract for the fourth battle-cruiser, both hull and machinery, and under these circumstances the trade outlook in Glasgow and the West of Scotland generally should become much brighter. These Government orders will mean the employment of some 12,000 to 20,000 men for several years, the number depending upon the speed at which the vessels are to be built. The news that the above firms had been successful in their tenders has given unbounded satisfaction in this district because so many branches of industry will benefit both directly and indirectly.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The condition of the Welsh coal trade remains as unsatisfactory as ever. The number of idle collieries has been increased in consequence of the impossibility to secure remunerative business, while numerous pits are working short time. As a result some thousands of colliery workers are idle, while many are working only two and three days a week. Despite this the demand is still insufficient to absorb outputs, and as buyers anticipate that prices have not yet touched bottom, wherever practicable they are holding off. At present best Admiralty large coal is obtainable at 28*s.* 6*d.*, with best Monmouthshires round 27*s.* 6*d.* and Eastern Valleys 26*s.* Smalls, however, remain scarce, as collieries are stocking a proportion of these for use under their own boilers. Best steam smalls command from 18*s.* 6*d.* to 19*s.*, ordinaries 17*s.* to 17*s.* 6*d.*, cargo sorts 16*s.* to 17*s.*, and good drys 15*s.* to 16*s.*, but the prices vary according to the proportion of large buyers are willing to take. In many cases colliery salesmen refuse to sell small without large. Foreign exports in the past week totalled 440,000 tons, compared with 385,000 tons in the preceding week, and 546,000 tons in the corresponding week of 1913. A considerable proportion of the coal now being sent abroad is on account of contracts arranged at the end of 1920 and 1919, the prices of which have been readjusted. An idea of the dissatisfaction of the men with the Miners' Federation is expressed in a proposal of the Cwm Colliery Lodge, Pontypridd, to reconstruct the federation. In a manifesto to the men they say "since the strike, colliery workmen of South Wales have been waiting for someone to move in the matter of the reconstruction of the Miners' Federation; men have ceased paying their contributions, and as a result the organisation has practically ceased to function." It is not anticipated that the Cwm Lodge will receive much support, but the proposal is significant of the feeling amongst the men.

The Iron and Steel Trades.—Costs in the Welsh tin-plate trade are more closely approximating selling prices, with the result that business has been rather more active and the outlook is considered more hopeful. At any rate merchants are stated to be buying forward and for November-December shipment 21*s.* 6*d.* f.o.b. has been paid. For prompt plates prices range from 21*s.* to 22*s.* 6*d.* The wages reduction as a result of the recent ascertainments of selling prices which comes into operation on November 6, represents a fall of about 1*s.* per basis box of tin plates.

NEW STEAMSHIP SERVICE TO AUSTRALIA.—Steamship communication with Australia is being actively furthered by the inauguration of a new service of large fast vessels specially built for the Commonwealth Government Line. They have ample passenger and cargo capacity, and by omitting Mediterranean ports it is claimed that they will accomplish the voyage in at least three or four days quicker time than any other line to Australia, including mail service lines. Five new steamers of uniform register of about 14,000 tons and of high speed have been built. Each bears the name of an Australian coastal bay: Moreton Bay, Largs Bay, Hobsons Bay, Jervis Bay and Esperance Bay—being thus representative of the five largest States of the Commonwealth. They are of uniform design, and are fitted with every modern appliance to ensure rapid and safe handling of cargo, of which, owing to the size of the hatches, nature of gear, &c., all classes can be carried. Special facilities and compartments are provided for the stowage of special cargo. Lowest current rates of freight will apply to and from Colombo as well as Australia. Passenger accommodation is of the most modern type. Only a small number of first saloon passengers will be carried, the bulk of the room being available for third-class to a total of over 700, in two, four and six-berth cabins. The Moreton Bay, the pioneer of the new line, is timed to leave London on December 7, and the other ships of the "Bay" class will follow her at four-weekly intervals. They will proceed direct from London to Port Said, thence to Colombo and Australia, calling in turn at Fremantle, Adelaide, Melbourne, Sydney, and making Brisbane the terminal port. This new service of Australian steamers is in addition to the large cargo fleet already running, and which will be continued.

NOTICES OF MEETINGS.

INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 28, at 6 p.m. at Storey's Gate, St. James' Park, S.W.1. Extra meeting at which the discussion on the Eleventh Report of the Alloys Research Committee on "Some Alloys of Aluminium," will be resumed.

THE PHYSICAL SOCIETY OF LONDON.—Friday, October 28, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, London, S.W. The following papers will be read: (1) "On the Use of Anderson's Bridge for the Measurement of the Variations of the Capacity and Effective Resistance of a Condenser with Frequency," by Mr. S. Butterworth, M.Sc. (from the National Physical Laboratory); (2) "Notes on Earth Capacity Effects in Alternating-Current Bridges," by Mr. S. Butterworth, M.Sc.; (3) "An Automatic Voltage Regulator," by Mr. F. G. H. Lewis (with demonstration); (4) "The Flow of Viscous Liquids through Slightly Conical Tubes," by Professor A. S. Hemmy.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, October 29, at 7 p.m., at the Education Offices, St. James's-road, Dudley, the President, Mr. James Payton, will deliver an address.

THE BRADFORD ENGINEERING SOCIETY.—Monday, October 31, at 7.30 p.m., Lecture in the Hall of the Bradford Technical College. Mr. H. T. Newbigin, A.M.Inst.C.E. (of Newcastle-on-Tyne), on "Michell Bearings," illustrated by lantern slides.

THE INSTITUTE OF MARINE ENGINEERS, INCORPORATED.—Tuesday, November 1, at 6.30 p.m., the President's Address.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday' November 1, at 6 p.m., Session 1921–22, Opening Meeting. Address by Mr. William Barton Worthington, President, and presentation of medals awarded by the Council. [The President will receive the members in the Great Hall after the meeting.]

THE ROYAL SOCIETY OF ARTS.—Wednesday, November 2, Inaugural Address of the 168th Session on "Wireless Telegraphy" (illustrated by experiments), by Alan A. Campbell Swinton, F.R.S., Chairman of the Council. The chair will be taken at 8 p.m.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 2, at 8 p.m., at the Royal Institution, Colquitt-street, when the President, Mr. J. B. Wilkie, M.I.Mech.E., M.Inst.N.A., will deliver his Inaugural Address.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, November 3, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi. "The Manœuvres of Getting off and Landing," by Squadron Leader R. M. Hill, M.C., A.F.C. At the request of the Aeronautical Research Committee, this paper was published in advance in the *Aeronautical Journal* for October, and it has also been published as a report and memorandum by the Aeronautical Research Committee.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 3, at 6 p.m., in the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, the president, Mr. J. S. Highfield, will deliver an Inaugural Address.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON): SCOTTISH CENTRE.—Thursday, November 3, at 7.30 p.m., in the Societies Room, Royal Technical College, George-street, Glasgow, when an address will be delivered by Mr. Robert H. Whitelegg, Chief Mechanical Engineer, Glasgow and South Western Railway Company.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 4, at 6 p.m., the Thomas Hawksley Lecture will be delivered by Dr. H. S. Hele-Shaw, F.R.S., Vice-President. Subject: "Power Transmission by Oil."

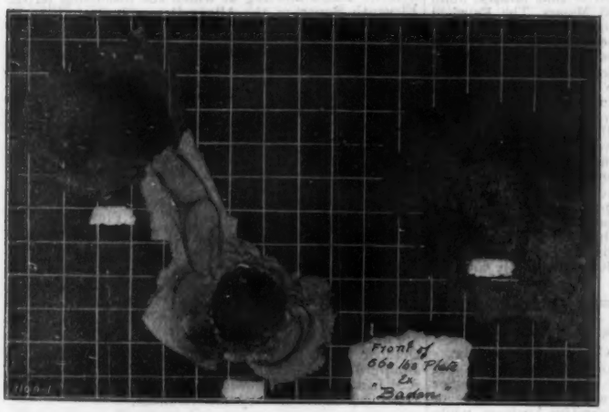
THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 4, at 8 p.m., at Caxton Hall, Lecturette: "Timber Trees of Commerce," by Mr. T. H. Ivey (delivered by Mr. W. Ivey).

SOCIETE DES INGENIEURS CIVILS DE FRANCE.—The hon. secretary, British Section, of the French Society of Civil Engineers, 45, Great Marlborough-street, W. 1, announces that an extraordinary meeting will be held on Wednesday, November 2, at 5.30 p.m., at the Institution of Mechanical Engineers. The chair will be taken by Mr. Raymond Poincaré, Past President of the French Republic, and a paper will be read by the Marquis de Chasseloup-Laubat, on "The Efforts of France in the Reconstruction of the Devastated Regions." Admission is not confined to members of the society.

RADIOTELEGRAPHIC METEOROLOGICAL SERVICE IN SWITZERLAND.—The Swiss central meteorological office at Zürich had been in radiotelegraphic connection with the Eiffel Tower since 1912, and for some time the Federal meteorological service was one of the best in existence. The war developments in other countries left Switzerland somewhat behind, however, because Zürich was provided with old-fashioned antennæ, whilst modern stations mostly work with coil or frame aerials for undamped waves. Two of these latter, designed for a wide range of wave-lengths, are to be fixed near the building of the Physical Institute of Zürich, which will have to be enlarged for this purpose, lest the working of the new apparatus should inductively affect the measuring instruments within the building. The radiotelegraphic station at Bern is also to be utilised for the service.

RESULTS OF TESTS OF GERMAN ARMOUR PLATES.

(*For Description, see page* 610.)



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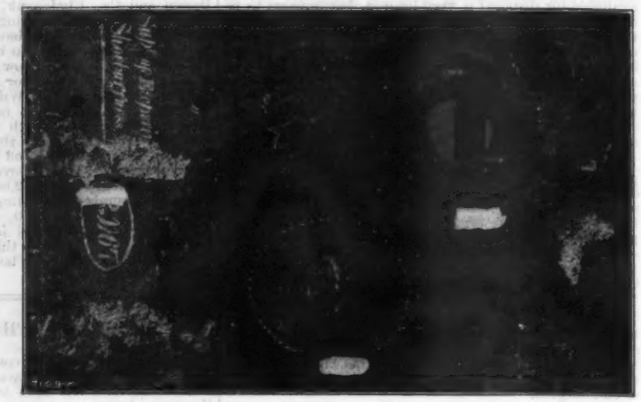

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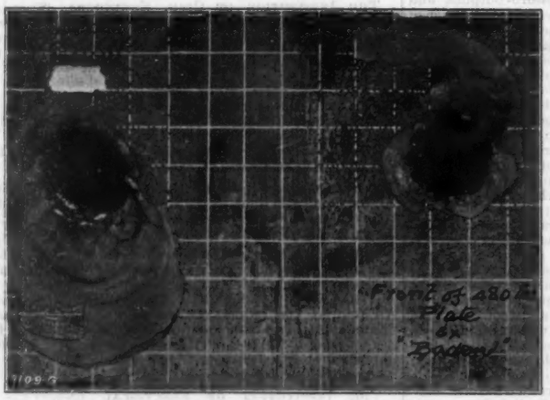

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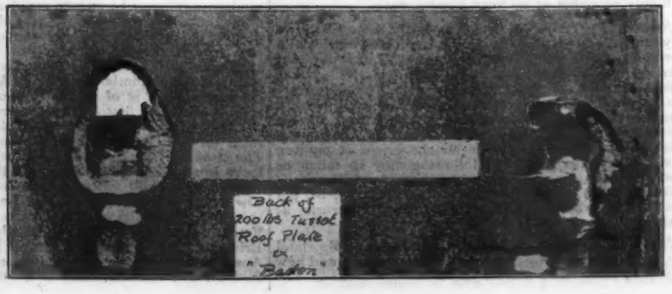
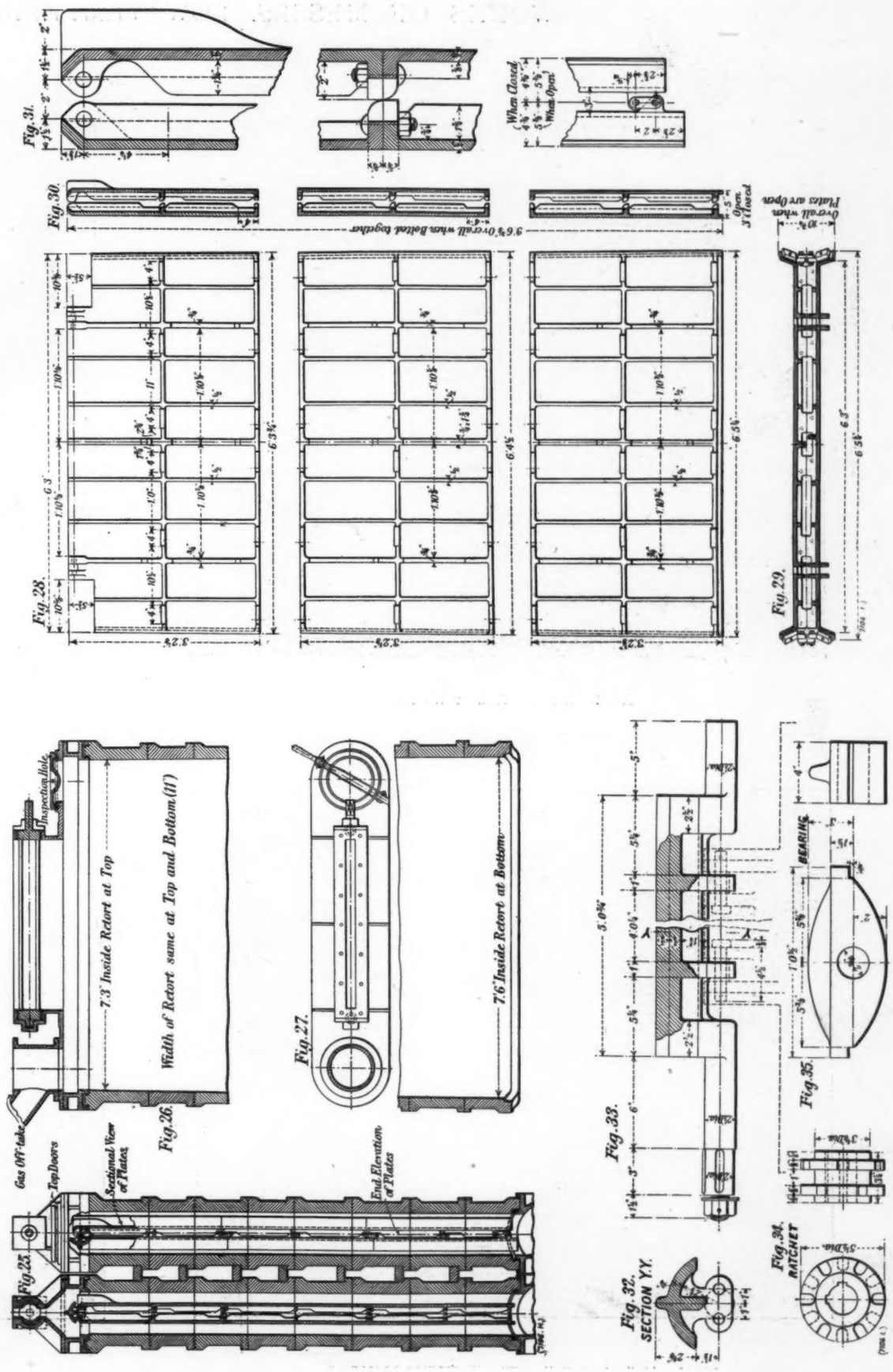


Fig. 8.

WORKS OF MESSRS. LOW TEMPERATURE CARBONISATION, LTD., AT BARUGH, NEAR BARNSLEY.

(For Description, see Page 596.)



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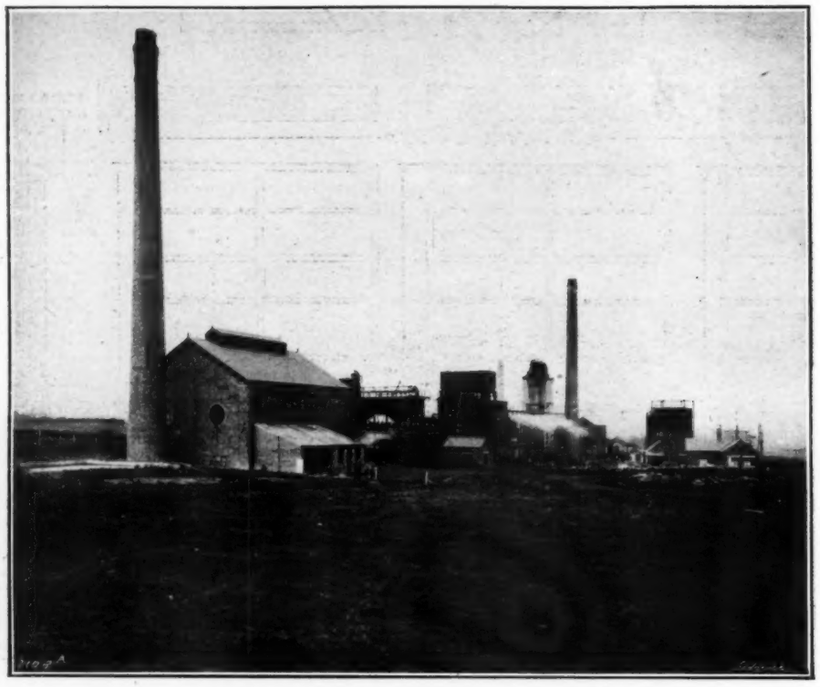


Fig. 1. General View of Works.

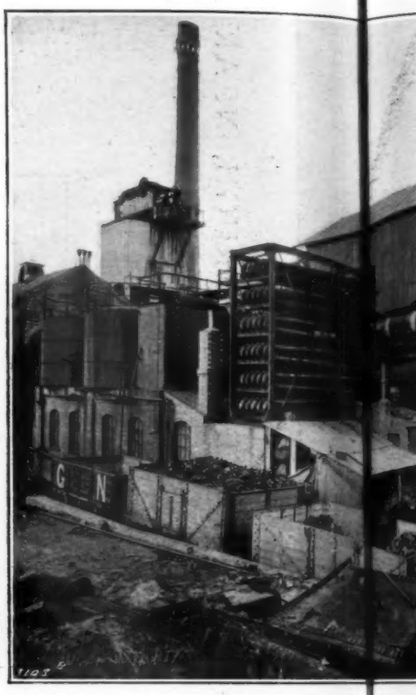


Fig. 2. View showing Gas [Co]oler a

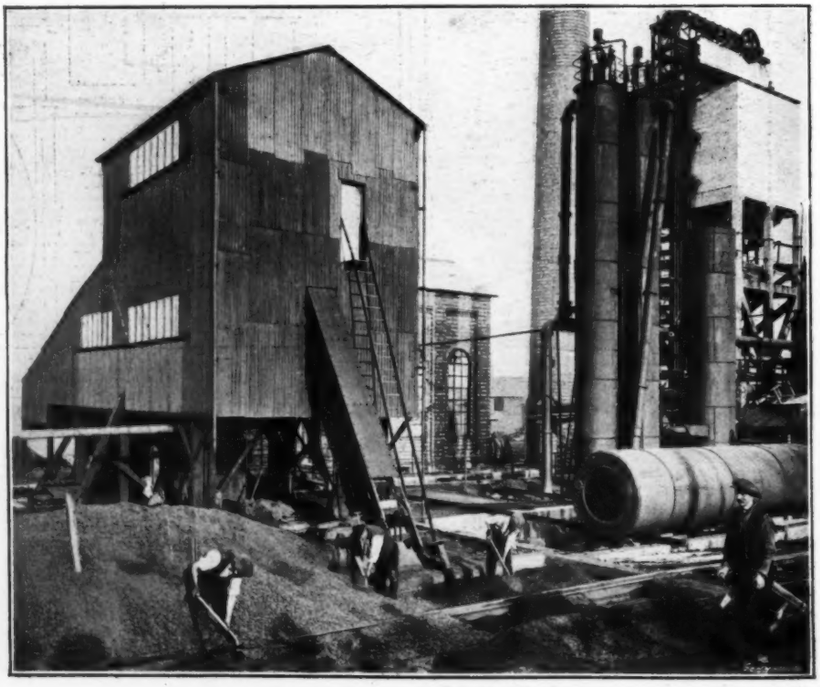


Fig. 4. View of Coal Washer and Benzole Scrubbers.

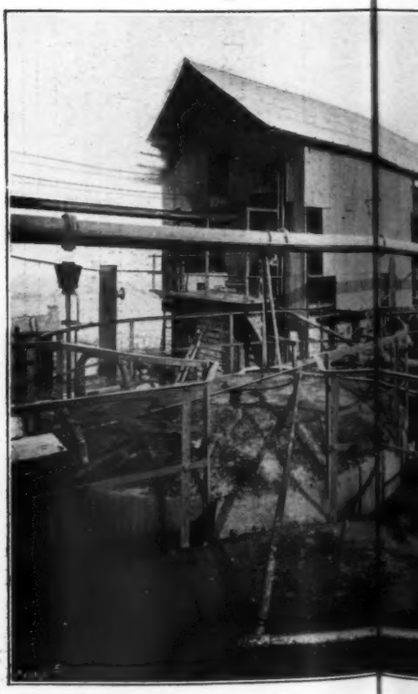


Fig. 5. Retort House wit[h] Stora

...BONISATION LIMITED, AT BARUGH, NEAR BARNSLEY.

(Description, see Page 596.)

...s Gas Cooler and Tar Storage Tanks.

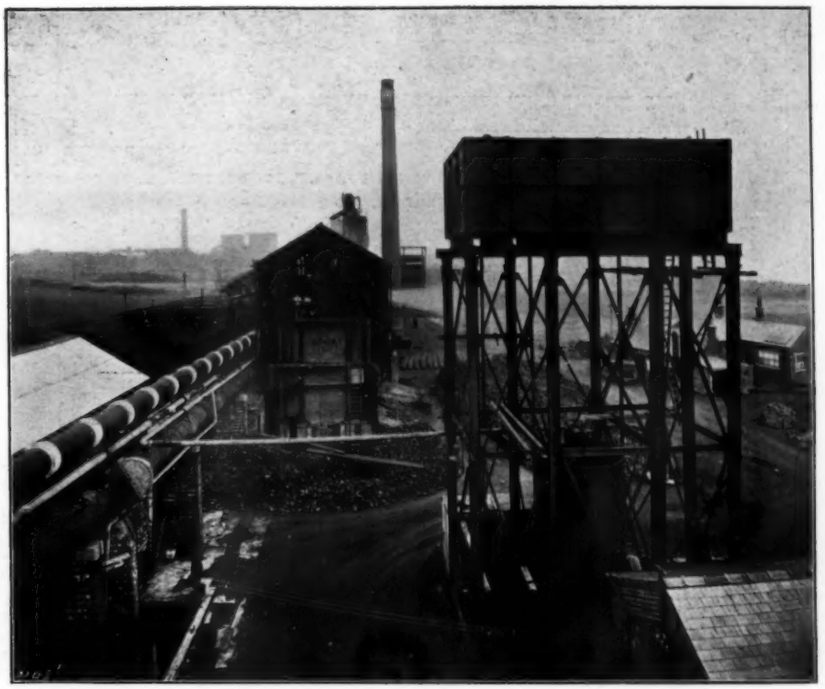


Fig. 3. View showing 20-In. Concrete Gas Main to Retort House.

...se with Storage Tanks in Foreground.

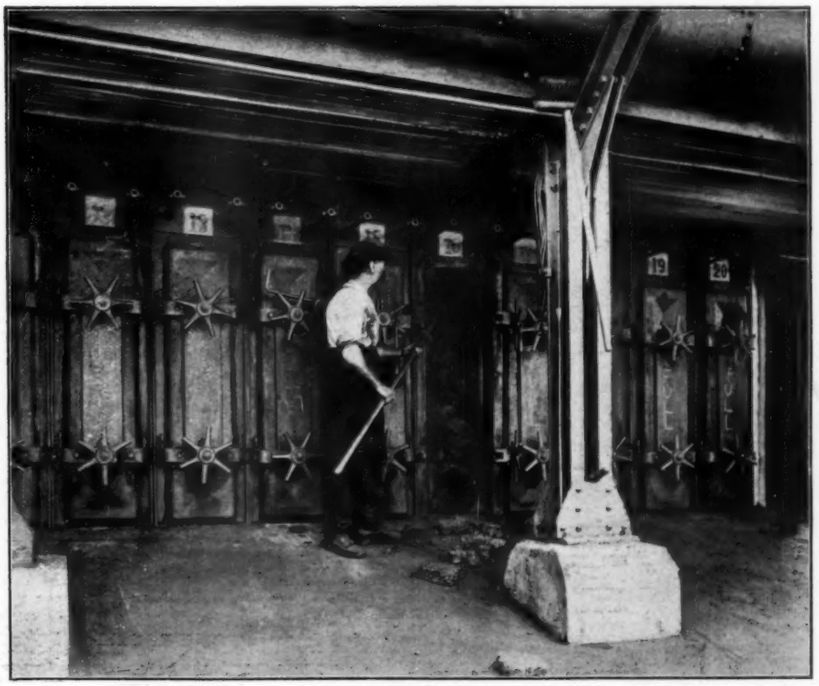
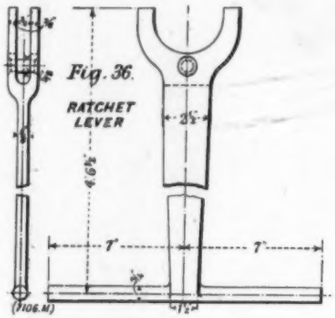


Fig. 6. Withdrawing Coalite from Cooling Chambers.

WORKS OF MESSRS. LOW TEMPERATURE CARBONISATION LTD., AT BARUGH, NEAR BARNSLEY.

(*For Description, see Page 596.*)



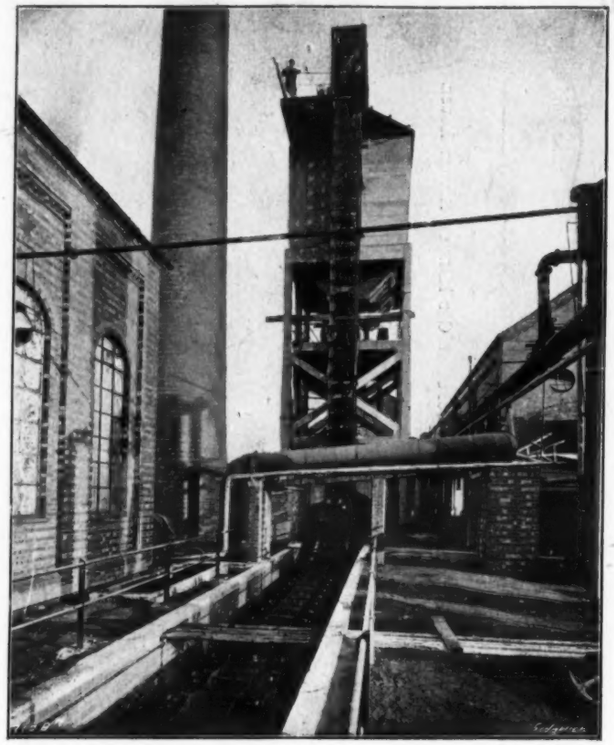


FIG. 38.

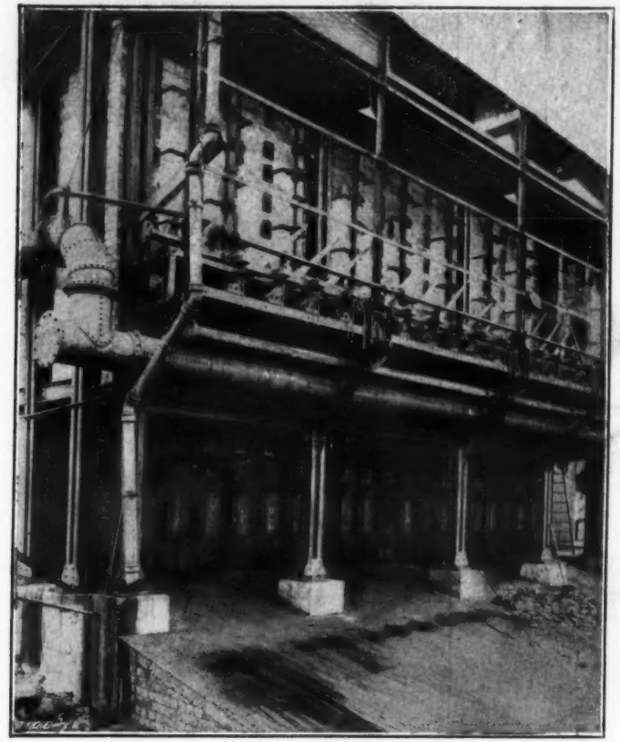
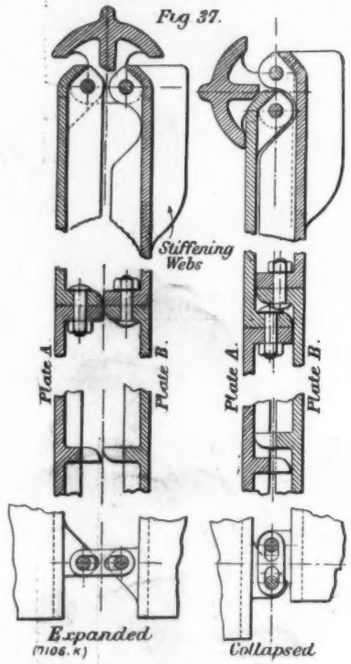
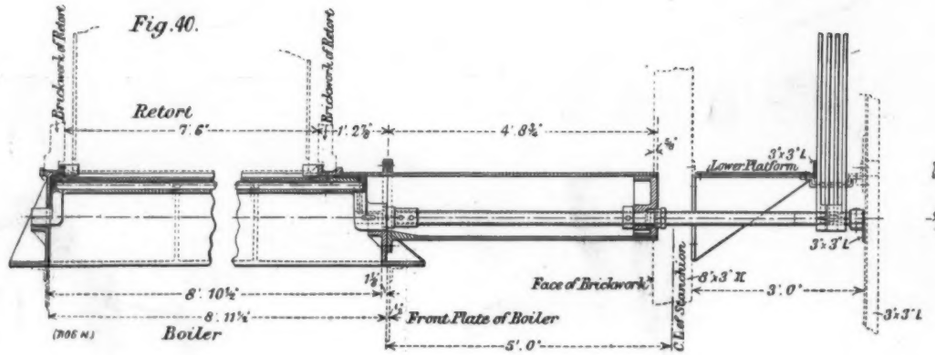
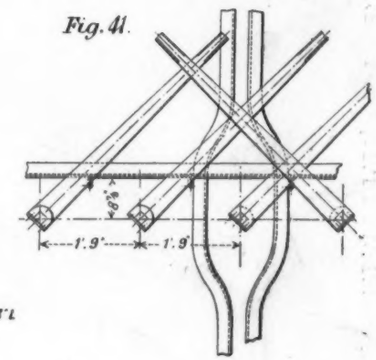


FIG. 39.







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ADVERTISEMENT RATES.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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With One Two-Page Plate and Two One-Page Plates of the WORKS OF MESSRS. LOW TEMPERATURE CARBONISATION, LIMITED, AT BARUGH, NEAR BARNSLEY.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 608.

ENGINEERING.

FRIDAY, OCTOBER 28, 1921.

THE DISTRIBUTION OF WARSHIP CONTRACTS.

IT is cause for some satisfaction that the decision to build further battle-cruisers was taken before our present industrial troubles arose. Unemployment rightly holds a very prominent place in the councils of the nation at the moment, but it is in every way undesirable that considerations induced even by extensive unemployment should dictate naval policy, and it is conceivable that in the absence of any settled naval plan the present state of industry might have resulted in the too hasty production of one. That this is so is illustrated by the fact that the placing by the Admiralty of orders for the four new battle-cruisers is generally regarded mainly from the point of view of the employment they will bring, and that their relation to the future naval strength of the country is treated by some as quite a secondary matter. The fact that these orders can now be placed is matter for great satisfaction, and they will have a very beneficial effect on the unemployment in the engineering trades, but it is well to remember that they represent an order of event quite different from such a decision as, for example, to employ certain unemployed on the levelling of a piece of land for the purpose of forming a recreation ground.

As will be generally known, three of the ships are to be built on the Clyde and one on the Tyne. This will naturally be matter for much satisfaction in Glasgow, but in some other places criticism may be expected. It is being suggested that the Government should have distributed the vessels as equally as possible throughout the shipbuilding centres in order to distribute the employment they will bring. This is, of course, the point of view to which we have already referred, and which almost regards the building of these ships as a type of relief works, rather than as a naval matter of the first importance. If the Admiralty on a consideration of the tenders they have received have come to the decision that on the score of price, or other relevant consideration, the country will obtain the best value for its money on the Clyde, there can be no matter for criticism.

To the Clyde, and the Tyne in smaller measure, the matter is naturally of great importance, and early next year the orders should give employment to some 2,000 men on each ship. Some few months must, of course, elapse for the making of drawings and patterns and the getting out of orders for materials, but after that time the employment created will be very considerable. It is very possible indeed that the placing of these orders will act as a stimulus to the whole industry. This would be in accordance with experience which has shown that the placing of Admiralty orders in times of depression has not infrequently had a widespread effect. If this is considered too hopeful a view it is well to remember that ultimately these four ships will call for the ordering of a great many million pounds worth of engineering material, and looking at the industry as a whole, it will be realised that this must represent the setting in motion of many productive units now nearly idle, and an overall reduction in the incidence of standing charges. As the ships are paid for with public money they represent no accretion to wealth of the country, but they, at the least, represent a more profitable expenditure than the carrying out of unwanted relief works, or the paying away of unemployment doles.

Although the hope of some that these four ships should be distributed round the coasts has not been realised, it is not to be supposed that they will not bring much work to centres other than those to which the orders have been allocated. This point of view is probably entirely overlooked by the general public, while even many engineers may fail to realise how very widespread the work for these ships must necessarily be. Even the main contracts do not, of course, cover guns, and Sheffield, Glasgow, Newcastle and Manchester will share; in orders for armour plate Sheffield, Glasgow and Manchester will participate; while for gun mountings Barrow and Elswick profit. These being main contracts have no doubt come to the notice of the public, but sub-contracting work and the employment created in the manufacture of the material required are perhaps likely to be overlooked.

A brief and very incomplete summary of the work which a battle-cruiser involves will perhaps give even engineering readers a more accurate idea of what these orders mean to the engineering industry. Apart from a large proportion of the iron ore and similar supplies, which have to be imported, the material and work are practically entirely British. The standard materials of shipbuilding—plates, angles, &c.—are made in several districts in the north of England as well as in Scotland, and the building of a ship on the Clyde does not necessarily mean that the material is rolled in the same district. Considerations of this kind apply even more strongly to machinery equipment. The machinery is not, of course, wanted by the shipbuilders in an early stage of the work, but the engine builder requires his raw material very early, and some important contracts for work of this kind should be placed very soon. It is not uncommon for a marine engine works to obtain large forgings and castings outside, and items of this kind will be required fairly soon and may be expected to increase employment in Scotland, Yorkshire, Lancashire and the Midlands. Other material which the engine builder does not make for himself includes condenser tubes, boiler tubes, turbine blading, &c. Orders for material of this kind should shortly benefit Birmingham, South Wales, Manchester and parts of Yorkshire.

An even larger field from the point of view of the distribution of work throughout the country is offered by the auxiliary machinery. Such items as feed pumps, circulating pumps, air pumps, refrigerating and distilling machinery and electrical equipment will be required in very large quantities. Many of the items in this list, or items of a somewhat similar type, have been made a speciality of by firms distributed over almost the whole countryside. Many of the firms who manufacture equipment of this kind are situated in our medium-sized or smaller country towns, and the battle-cruisers building on the Clyde are likely to bring employment in many places very far from Glasgow. The Admiralty necessarily exercise some control of the placing of sub-contracts for items of this kind, and in view of the peculiar conditions at the present time one may expect that, consistent with material of the necessary standard being obtained and consistent also with price considerations, they will endeavour that this auxiliary work shall be distributed as fairly as possible throughout the country.

This list of the material involved in a modern battle-cruiser is obviously very incomplete, but it illustrates the point that the work which the Admiralty have called for is of interest to many other places than the two shipbuilding centres which figure in the main contracts. The distribution of work we have suggested will be seen to be far from complete if one considers the internal equipment of the ships beyond the machinery proper. This material in the main will belong to a slightly later period in the history of the ships, and will not in general be required in the first stages, but it will be good for business if it is merely known that important contracts are coming forward. The equipment material will cover thousands of fittings of all kinds, furniture, electric cables, piping, electrical and navigating instruments, and dozens of other things which it is needless to specify. It would be impossible for any one to state in detail the towns which this work will benefit, but it is very evident that they will be distributed throughout the length and breadth of the land.

A final point, which may be dwelt on for a moment is that the whole of the work will be done at home. The Admiralty have for many years specified that all material supplied to their specifications should be of British manufacture, and they have been very strict in seeing that their condition was com-

plied with. In the past an exception was made in the case of boiler tubes which were made from Swedish billets, but even these are now made from British steel. This is a matter in which difficulties have been met, but Admiralty persistence, combined with the skill of our manufacturers, have now overcome them. A further item has, we think, in the past been of foreign manufacture. This was the gyro-compass, which was not first developed in this country. An independent British instrument has, however, now been perfected and we trust the all-British ships may be complete even to this item. This small but important auxiliary itself would mean a considerable amount of work for British labour.

INDUSTRIAL AND SCIENTIFIC RESEARCH.

In the dark days following Jena the Prussian Government, though called upon to pay crushing war levies, managed, nevertheless, to find the funds required to establish the University of Berlin. In the evil times which have now fallen upon us the Treasury, so far from emulating the courage and insight of the advisers of the Hohenzollern in 1806, have called upon the Department for Scientific and Industrial Research to reduce its expenditure for the coming year by 20 per cent., thus treating the department on the same basis as those which employ whole armies of clerks to do work much of which would be unnecessary were our public departments run on more rational lines. Nevertheless, the nation is to be congratulated on the fact that matters are no worse. The scientific worker has at length been placed on a par with the ordinary official, instead of being regarded as on an entirely different and much lower plane. It is to be hoped that the new attitude will be maintained and that we shall no longer, as was common 20 years ago, see departments advertising for highly-qualified chemists and physicists at a wage little in excess of a labourer's. Indeed, we may hope ultimately to attain a condition of affairs in which the possession of scientific and technical knowledge will not be considered a disqualification for the headship of a Government Department concerned, say, in the operation of telephones and telegraphs or in the supervision of mines and shipping.

Of the one million sterling with which the Department was endowed in 1917, a balance of 903,205*l.* remains, but much of this is earmarked for researches either sanctioned or already in progress. Fortunately, the interest on this fund constitutes only a small fraction of the total income of the Department, which in the past financial year amounted to 462,650*l.*, of which 373,821*l.* came from the Exchequer and some 51,000*l.* from fees for work done at the National Physical Laboratory and elsewhere. It will be remembered that the Royal Society felt itself compelled a few years ago to abandon any financial responsibility for the National Physical Laboratory. Since the cost of the Laboratory was about 204,000*l.* in the last financial year, whilst the receipts were but 45,770*l.*, it would seem that the action was wise. It should, however, be noted that the above statement of income and expenditure does not represent quite fairly the actual facts, since much work done for the Services and for other Government Departments was not charged for. In the future this will not be the case, and the cost of investigations made for other Departments of Government will appear in the accounts of those Departments, and not be debited to the National Physical Laboratory. Steps are being taken, moreover, for the interchange of information between the Services, which have many problems in common. Similarly, where researches made primarily for military ends yield results of interest to our manufacturing industries they will, so far as considerations of national safety permit, be published.

By co-ordination of this kind overlapping will be reduced, but the Committee insist strongly (a point which has been repeatedly urged in Engineering) that the total abolition of overlapping would be fatal to progress. The maintenance of independent centres of thought is of prime importance, though it is, of ocurse, desirable that there should be frequent intercommunication of results. The original intention of the Committee which considered this matter of co-ordinating researches was that where the experimental work of the fighting Services was of particular importance to science or industry, the investigation should be financed by a co-ordinating board. One difficulty soon arose, viz., to determine in the initial stages whether or no a particular research was of industrial importance. Thus the "Leader gear," introduced by the Admiralty, promises now to prove of very substantial value to the mercantile marine; but it is highly improbable that any commercial association would have financed the necessary experiments. It was the naval necessities which led to the rapid development of the idea, and these are no longer pressing. The Admiralty consequently proposed to abandon further experiments on the matter, but the Physics Board came to the rescue and provided the necessary funds. In a similar fashion the Board believe that the acoustical researches now being carried out by the Services could be extended with benefit, and are, consequently, contributing to the cost.

The report notes that there are two classes of technical research, viz., along the straightforward obvious line of attack, which is almost bound to yield results, given an intelligent and industrious observer, working in a properly-equipped laboratory, and the indirect method, where it is ever uncertain whether any directly useful results will be achieved, and where success depends relatively little on equipment, but mainly on the man. When, however, useful results are obtained in this way they may revolutionise an industry, which is seldom the result of a research of the straightforward type. The latter is, however, far better suited to Service conditions and, indeed, to the ordinary industrial laboratory. The revolutionary discovery commonly comes from the independent worker, who quite frequently is more interested in satisfying his native curiosity than in acquiring the subject matter for a patent. The Committee mention the use of X-rays for discovering flawed castings as one instance in which the straightforward method of attack is bound to yield results. It is, in fact, merely a question of developing the power used; but a preferable solution would be the discovery of methods which would not necessitate the expenditure of large powers. Along this direction, however, there can be no assurance that the time and money expended will achieve the end in view. Both methods of investigation, have, however, their appropriate fields. The ordinary business man and organiser may prefer the former method, but it is gratifying to note that the Cotton Industry Research Association is taking the more enlightened view. In addition to "directly useful" researches the programme of the Association includes an inquiry into fundamentals. The chemical and physical changes produced during manufacture are being thoroughly studied, and investigations are at present in progress on the structure of cotton fibre, the constitution of raw cotton, and on the deterioration of cotton goods by bacterial action. The British Photographic Association is also engaged in research work of a fundamental character, to which, indeed, it would seem to be limiting its activities, since the principal makers of photographic materials have generally their own laboratories available for the solution of such difficulties as may arise in their manufacturing operations.

The report contains a hint that certain of the associations already formed are showing signs of discouragement, which, in view of the state of trade, is perhaps not unnatural. When conditions necessitate the reduction of expenditure it is very understandable that firms, even if they may not adopt the accountant's classification of research work as "unproductive expenditure," may at least regard it as "speculative" expenditure and, consequently, be more inclined to economise there than in directions which may for the time being be more remunerative. We hope, however, that wiser counsels will prevail and that the temptation to sacrifice the future for the present will be resisted, strong though the impulse may be.

To all appearances it cannot be many years before the demand for petrol exceeds the available supply. In fact, present prices afford grounds for the belief that this condition has already been reached, and the question of substitutes will thus steadily become more and more insistent. It is of interest, therefore, to note that the Committee report that very good yields of alcohol have been obtained from Jerusalem artichokes and that there appears to be a possibility of turning the stems into paper. Should this prove feasible, they consider that the prospect of manufacturing power alcohol in this country will be considerably improved. There appears, however, little probability of this country being able to supply in this way more than a fraction of its requirements. Experiments are still in progress on different forms of cellulose, and recent experiments made by the Burmah Oil Company on rice straw give some promise of commercial success in the joint production of alcohol and paper from this raw material. Until alcohol can be produced from waste materials there is, the Committee hold, little probability of its proving possible to import it cheaply enough to satisfy our home requirements for motor fuel, though it may meet the needs of the locality where it is produced.

Some interesting work has been carried out for the food investigations board, which, amongst other matters, is concerned with questions of refrigeration. Experiments made during the year have shown that air is the principal agent in conveying heat across a space filled with ordinary insulating materials. Very little of the heat, it appears, flows through the solid portion of the packing. For this reason the apparent conductivity of cork varies greatly, being dependent on the form and size of the air spaces. Another interesting discovery was that the loss of heat from a wall can be greatly reduced by fixing horizontal bars across it, spaced about 2 ft. apart. The reduction thus effected in the rate of heat transfer is due to the fact that air in contact with the wall at the bottom is warmed and rises, picking up further heat as it ascends. At the outset the motion of the air is streamline in character, but after a rise of about 2 ft. the velocity attained is such that the motion becomes turbulent, and when this occurs, as repeated experiments have shown, the rate of transfer of heat between a solid and a fluid is enormously augmented. By placing a horizontal baffle across the wall this turbulent flow is deflected and a new air current is started above the baffle, which at the outset is, as before, of a linear character. So soon as the motion of this second current tends to become turbulent a second deflecting baffle is introduced. In this way it has been found that the loss of heat from a warm wall can be very materially diminished.

In view of the present excessive cost of building operations it is disappointing, though perhaps not surprising, to find that the Committee hold out no hope of revolutionary reforms, but expect merely to effect minor economies by scientific work along normal lines.

The use of compressed gases is steadily extending, and will be furthered by the adoption of high carbon steel containers. The recommendation sanctioning these is, however, not unanimous, since Mr. J. H. B. Jenkins, who represents the railway companies in the matter, dissents. Since the strain on such cylinders is of a remarkably steady character, there would seem no reason why high carbon steel should not prove satisfactory, provided that it can withstand without injury the processes of manufacture. No doubt the Committee have satisfied themselves that such cylinders can safely withstand such ill-usage as they will be liable to meet with during transport. The attitude of the railway companies is, however, readily intelligible. It may, however, be called to mind that some 50 years or more ago the companies were for similar reasons reluctant to venture on the use of steel rails, but that subsequent experience has proved their not unnatural fears to be groundless, and we trust that this experience may be repeated.

Vacuum vessels, for which we are indebted to Sir James Dewar, are now in almost universal use, and we learn from the report that very substantial improvements have recently been made in the methods of evacuation employed. This can now be effected in one-fourth the time previously necessary and a better vacuum is attained. The new process is, moreover, very much cheaper, the

cost of evacuating certain vessels for the Air Ministry having been reduced from 3*l.* to 3*s.*

Further experiments have been made on lubrication and have confirmed the results of previous observers on the extraordinary improvement effected by the addition of a very small percentage of rape oil to mineral lubricating oils.

Amongst its other activities the Department makes grants to students who are desirous of becoming research workers. Of these the supply in this country has hitherto been exceptional in quality, but relatively small in numbers. Under present conditions the latter defect is in course of being made good. The Committee complains, however, that many of the applicants are too young to have, in the generality of cases, acquired an adequate preliminary scientific training. Naturally there are exceptions, as some men at twenty are already distinctly the superiors of the normal student five or six years older. Apart from such exceptions, however, the Committee are not disposed to make grants for research to such youthful aspirants, and are, moreover, anxious that the final honours schools at the Universities should set so high a standard that the normal student could not possibly reach it at so early an age. In this connection we may perhaps call attention to one difficulty that has arisen in connection with the practice of certain Universities of awarding their higher degrees on the basis of original research. In this matter engineering students are very heavily handicapped. The chemical research student works with bits of glass and rubber tubing, and any really expensive apparatus he may require forms part of the normal laboratory equipment, and in the infinite variety of organic compounds he can always find some problem (often an easy one) which has not yet been definitely settled. To a lesser extent the student of physics is in a similar favourable position; but matters are far otherwise with the unfortunate engineering student. Nearly all the experiments which can be made with cheap and simple apparatus have already been repeated *ad nauseam*, and to carry matters further, would involve the construction of an excessively costly plant. No doubt the field for experiment with simple and cheap apparatus is not yet wholly exhausted, but it is certainly much narrower than that open to the chemist, and it will involve a much greater exercise of insight and originality to discover a region at once unexplored and yet attackable with inexpensive plant.

The Board very wisely are permitting many of their students in training to undertake a certain amount of teaching work. There is perhaps no greater incentive to clear thinking than the necessity of conveying ideas to others, and the practice will be at least as advantageous to the lecturer as to his class. Certain Universities, however, have attempted to make this permission an excuse for not paying the lecturer normal rates for his work, but we are glad to note that the ruse is meeting with the strenuous opposition of the Department, which will only sanction lectures by a research worker on the condition that he is properly remunerated for them. They hold that the provision of adequate teaching is the duty of the University, and that it is no function of the Department to provide any part of the necessary staff.

THE METALLURGICAL CHEMIST AND SHEFFIELD.

Sir Robert Hadfield, Bart., F.R.S., was to have delivered the opening address before the Sheffield Association of Metallurgists and Metallurgical Chemists at the Mappin Hall, the University, Sheffield, on Monday last. Unfortunately, Sir Robert had to undergo an operation more than a week ago, and Mr. S. A. Main, B.Sc., one of his assistants, had to speak on his behalf.

Sir Robert was not to address the Sheffield Association of Metallurgists and Metallurgical Chemists as president. It was by the request of the retiring and the actual presidents, Dr. W. H. Hatfield and Mr. P. B. Henshaw, that he prepared an opening address, following as regards papers and addresses in the footsteps of Sir Henry Fowler, Dr. J. E. Stead, Professor H. C. H. Carpenter, Dr. Rosenhain and others. Sir Robert himself had, in 1894, been the first president of the Sheffield Society of Engineers and Metallurgists; the association which he was to address last Monday was only founded four years ago. In 1894 the Sheffield Technical School had a roll call of 151 day students and 490 evening students, a total of 641 students compared with 99 of the first year, 1886–87. At the present time the total is not less than 3,546. This figure is made up as follows: University day students of arts, pure science, medicine and law, 836, of engineering and metallurgy 858, together 1,694 students; evening students of engineering 1,045, metallurgy 717, and arts 90, together 1,852 evening students and a grand total of 3,546 students.

Credit for guiding Sheffield's University education Sir Robert assigned mainly to Professor W. M. Hicks, who was for many years principal of the University, to Professor W. Ripper, now dean of the faculty of engineering, and to the late Colonel H. Hughes. Many other distinguished educationalists came from Sheffield or worked there, and industrials co-operated well with them. Huntsman was a Sheffield man, Sorby taught there, Bessemer, born in Hertfordshire, found his main support there, and the metallurgists and chemists, now engaged in practical and educational research and work at Sheffield, fully appreciate that pure science and applied science may be distinguished, but cannot be separated. During the war the Sheffield National Factories sent out 1½ million shells, many of large calibre, and the uses of the Hadfield manganese steel in helmets and in seamines, undetectable because non-magnetic, became in their ways as important as the shells.

Dwelling, in his address, also upon the advance of chemistry and metallurgy abroad, Sir Robert presented a list of British, American, French, Swedish, German, &c., metallurgical chemists, chiefly modern, of whom he counts, in the order stated, 39, 9, 12, 5, 5. He further referred to the advance of science as connected with the Royal Society. Parts of the address, he stated in his preface, were re-embodied from the address which he delivered last summer to the deputation of American Engineering Societies who presented him with the John Fritz medal.

In conclusion, Sir Robert quoted two dicta of more than historical interest. The first is the prediction concerning iron made in 1650 by Prebendary Joseph Glanvill, F.R.S., of Worcester: "Iron seemeth a single metal, but in its nature are many mysteries, and men who bend to them their minds, shall, in arriving days, gather therefrom great profit, not to themselves alone, but to all mankind." The other quotation Sir Robert found written in a prayer book of 1646, used by Oliver Cromwell and bearing his initials: "Qui cessat esse melior, cessat esse bonus." This is, as Sir Robert remarked, "Indeed a fine motto for all of us to contemplate and to ponder over, whether individually or nationally."*

INTERNATIONAL PATENT CONVENTION.

It is well known amongst inventors who file applications for letters patent that there is an International Convention covering most of the important countries of the world which provides certain privileges in such countries to those who have lodged applications in another State of the Union. One of these provisions is that anyone who has filed an application in, say, Great Britain, may lodge an application for the same invention in any other State under the Convention within one year and obtain the priority of his British date, so that broadly speaking this will amount to the same as filing applications both in this country and in the foreign State at the same date. This is the view commonly held, and it is accurate up to a certain point, but inventors often overlook the fact that in certain countries third-party rights might be obtained which would seriously prejudice the effect of the priority under the International Convention and would prevent the patent when granted being effective against the third party. From time to time this case arises, and, in fact, it has again recently risen.

Germany is one of the countries whose laws contain a clause dealing with these third-party rights. According to the laws of that realm the patent is of no effect against a person who at the time of the application has already used the invention within the country or made the necessary arrangements for using the same. Such person has the right to use the invention for the requirements of his own business in his own works or the works of others. This right, however, can only be inherited or disposed of together with the business. The German authorities do not regard the date of application in this section as being the date of the basic application in the first Convention state, but the date of application in Germany, so that a right of user during the life of the German patent may be acquired by a party which for the first time makes use of the invention in Germany during the interval between filing the application, say in this country, and the application in Germany. It is therefore desirable for inventors where possible not to take advantage of the full time accorded them under the provisions of the International Convention for filing their foreign applications, but, for their full protection, they should lodge the patent applications in foreign countries as soon after filing the British specification as possible, particularly if there is any likelihood of anyone from the foreign countries seeing their manufactures and commencing to manufacture abroad.

As British specifications are commonly lodged in the provisional form in the first instance and the complete document is not filed until many months after, it usually follows that foreign patents are not applied for until the British complete specification is prepared, because the foreign patent applications are of the nature of British complete specifications. That is one reason why inventors often delay filing their foreign applications, but a better practice is to file the British provisional specification and so secure the filing date, then immediately to prepare the more complex complete specification without waiting for the statutory period of nine months, which is permitted, and at the same time prepare such foreign applications as it may be desired to lodge. Alternatively, if it is feared that the invention may not be novel, and the cost of filing foreign applications not justified, then the procedure up to the filing of the British complete specification at an early date should be followed, and foreign applications prepared immediately the results of the British examiner's search are available, should those results show that foreign applications are reasonably justified.

* We may add that an illustrated edition of Sir Robert Hadfield's address is being published by Messrs. Charles Griffin & Co., London, and Mr. W. H. Seed, of Church-street, Sheffield.

Ability in Industry.—The fifth of the series of industrial lectures organised by The Industrial League and Council will be given at Caxton Hall, S.W. 1, on Wednesday evening, November 2nd, at 7.30 p.m., when the lecturer will be Mr. E. C. de Segundo, A.M.I.C.E., who will speak on "Ability as a Factor in the Production of Wealth." The gathering is to be presided over by Mr. John Ames, General Secretary of the league.

The Mackenzie River (Canada) Oil Company.—We read in *The Canadian Engineer* for the 6th inst., that Mr. A. H. Low, geologist for the Mackenzie River Oil Company, has returned to Edmonton from the Fort Vernon district (in the far north-west of Canada), and reports that the season's field operations were disappointing. No additional discoveries were made, and the well originally discovered has not proved to be a commercial producer. Mr. Low believes that there is oil in the Mackenzie district, but says that it may take several years of experimental work to locate it.

The Royal Society of Arts.—The one hundred and sixty-eighth session of the society will be opened on Wednesday, November 2, at 8 p.m., when Mr. Alan A. Campbell Swinton, F.R.S., Chairman of the Council, will deliver an address, with experiments, on "Wireless Telegraphy." Among the papers fixed for the meetings up to Christmas are the following: Professor John Ambrose Fleming, F.R.S., "The Coming of Age of Long-Distance Wireless Telegraphy and Some of its Scientific Problems" (Sir Henry Trueman Wood Lecture); Sir Walter Beaupre Townley, K.C.M.G., Minister to the Netherlands, 1917–19, "Trade with the Netherlands East Indies"; Mr. Alfred Henry Ashbolt, Agent-General for Tasmania, "An Imperial Airship Service"; Mr. Frederick Coate Wade, B.A., K.C., Agent-General for British Columbia, "British Columbia—The Awakening of the Pacific." A course of lectures on "Processes of Engraving and Etching" will also be delivered by Mr. Arthur M. Hind, Assistant Keeper, Department of Prints and Drawings, British Museum.

NOTES.

New Electric Generating Station at Blackburn.

On Friday last the new power station at Blackburn, which has been built from the plans of Mr. Wheelwright, the engineer and manager of the Blackburn Electricity Department, was formally opened. The station is to contain two 10,000-kw., 6,600-volt, 50-cycle turbo generators of the English Electric Company's manufacture, the first of these only being installed at present. It is expected that the complete plant will be in operation early next year. The boiler-house will contain seven cross-drum Babcock and Wilcox boilers, each having a normal evaporation of 50,000 lb. per hour, and furnishing steam at 210 lb. pressure and superheated to 600 deg. F. The grates are of the forced draught chain-grate type, and are all fitted with Lea coal meters. Ashes are dumped into small wagons working below the ashpits, and these are removed by an electric locomotive and hauled away for final deposition on a site which is to be levelled up. It is estimated that the whole of the ashes for many years can be disposed of in this way. Make-up water for the boilers is supplied by an evaporator, so that no water-softening plant is needed, and the boilers always receive pure soft feed-water. Three turbine-driven boiler feed pumps are installed, each capable of supplying the demands of three boilers. The circulating water is cooled by means of four cooling towers, the evaporation being made up from a well on the site. It is also possible to obtain water from a neighbouring canal for condensing purposes.

The Institution of Automobile Engineers.

The annual dinner of the Institution of Automobile Engineers was held at the Royal Automobile Club, Piccadilly, on Wednesday last, the president, Mr. George W. Watson, M.I.Mech.E., being in the chair. In proposing the toast of the Institution, Sir Arthur Stanley complimented the council on the systematic policy pursued with regard to the nature of the papers selected for presentation to the members, these being so chosen that they provided a definite course of instruction in their respective subjects. The president, in his reply enlarged upon this point, and also referred to the valuable moral and practical support which the Institution received from the Society of Motor Manufacturers and Traders, which by a grant of 2,000*l.* per annum for a period of years had enabled the Institution to carry out work which otherwise would have been impossible. Mr. Watson, further, made a strong appeal for the members to interest themselves in the welfare of the graduates by giving them facilities to observe processes of manufacture in their works and by deputing some capable and sympathetic member of their staff to explain the processes and to answer questions. In replying for the guests, whose health was proposed by Sir Henry Fowler, Mr. A. S. Mays-Smith referred to the commercial importance of the light pleasure car and Lieutenant-General Sir Travers Clarke, K.C.M.G., indicated the intention of the Army Council to "mechanicalise" army divisional trains. The army were going to rely even more on mechanical transport in the future than in the Great War. Great Britain was the first nation in the world to take such a step as he had indicated, and our boldness was due to the closeness of the touch between officers and civilian engineers.

Negligence and Liability of Ship Repairers.

An interesting case involving questions of the liability of ship repairers was decided by Mr. Justice Greer on October 24. (Reynolds *v.* The Boston Deep Sea Fishing and Ice Company, Limited.) The plaintiff was the owner of a steam trawler, the engines of which developed some defect in December, 1919, and the trawler was sent to be put on defendants' slipway for examination. She was put on the cradle and was drawn out of the water, but for some unexplained reason fell over on her side and was damaged. The plaintiff claimed damages, including damages for the loss of the use of the trawler. The claim was based on alleged negligence on the part of the defendants, the plaintiff claiming that the occurrence spoke for itself (*res ipsa loquitur*), and that the mere fact that the accident had happened showed that there had been negligence. The defendants denied this and stated that they had taken the same precautions as they always took in such cases; that hundreds of vessels had used the slipway without accident; and that there had been no negligence on their part. On this part of the case Mr. Justice Greer was in favour of the plaintiff. He pointed out that if he were to accept literally the evidence for the defendants to the effect that there had been no negligence it would be practically impossible in such cases for the plaintiff, who was not present when the accident happened and could not say of his own knowledge what had happened, ever to recover. On the occasion in question the weather was good and the tide suitable, and there was no suggestion of any latent defect in the apparatus which might have excused the defendants, and the defendants as bailees for reward were bound to deliver the article bailed in as good a condition as it was in when they received it, unless they could show that the damage occurred notwithstanding reasonable care on their part. His Lordship held that the accident could not have happened if reasonable care had been used, and from the fact that it had happened he was driven to conclude that there had been some negligence. There was, however, another important point in the case. The defendants relied on the following clause in their regulations for the use of the slipway, which was held to be applicable to the contract: "All persons using the slipway must do so at their own risk, and no liability whatever shall attach to the company for any accident or damage done to, or by, any vessel either in taking her to the slip or when on it or when launching from it." The plaintiff contended that as there were no words expressly relieving the defendants from liability for negligence the clause did not protect them against liability. His lordship held that whatever might be the effect of such a clause in the case of a common carrier the clause was sufficient to protect the owners of the slipway from liability for negligence. He thought that the words "no liability whatever" in a case of this kind excluded liability for negligence. He accordingly gave judgment for the defendants.

The Geology of the Egyptian Oil Field.

The winter session of the Institution of Petroleum Technologists was opened recently with a paper by Dr. W. F. Hume, of the Egyptian Geological Survey, on "The Geology of the Egyptian Oil Field." In the main, we learn from the paper, this oilfield is centred near a mountain range which was known to the Romans as Mons Petroleus. This famous spot is situated on the western shore of the Gulf of Suez, 163 miles south-east of Suez, at the foot of the Gebel Zeit, 1,400 ft. in height. The history of these oilfields, as outlined by Dr. Hume, may be considered both as discouraging, inasmuch as a good number of enterprises were abandoned, and as encouraging, because since 1913 some 5,000 tons of oil have frequently been mined per week. When the Société Soufrière began to exploit the peninsula of Gemsa, 12 miles south of the Zeit, in 1865, and tunnelled the gypsum close to the sea shore, oil collected in the excavations. By 1884 the Government had become interested; Colonel Ardagh found oil at a depth of 137 ft., and 100,000*l.* were spent, but the Government did not proceed with the search for oil. Mr. L. H. Mitchell and Colonel Stewart reported on further work in 1887. When the new Geological Survey of Egypt was commenced by Colonel H. G. Lyons in 1896, Dr. Hume, just coming from Baku, was not favourably impressed with Gemsa and the Zeitia pools; the geology of the district offered many puzzling and unpromising features. In 1908 the Egyptian Petroleum Company received a favourable report by Mr. D. A. Sutherland and the late Mr. D. A. Louis; the further explorations were carried out under Government supervision, but at Gemsa the supply fell off rapidly. Mr. John Wells extended the search to the small islands off the shore, and Dr. Hume himself discovered in 1911 an oil-smelling limestone on the western anticline of Hurghada. The Anglo-Egyptian Oil-Fields, Limited, had already been attracted to that district, on which Government and private interests have since been concentrated with very satisfactory results. Dr. Hume attributed importance to the circumstance that Mr. Vernon, geologist of the company just mentioned, was permitted to exchange notes with him. From the absence of petroleum in the older formations Dr. Hume concludes that iron carbides and similar compounds had nothing to do with the origin of the Egyptian petroleum. There is evidence of an extremely slow submergence of Northern Egypt and Sinai beneath a sea advancing from the north; the ancient coast was eroded, and a vast amount of organic matter was brought down, as evidenced by the carbonaceous shales stretching from Edfu, in the Nile Valley, through Hurghada to the eastern borders of Sinai Peninsula. These deposits are full of plant leaves, which attracted marine organism, and bituminous coal; the finer vegetable material was carried further out to sea and, under subsequent earth-changes, became converted into petroleum. Dr. Hume distinguishes three oil districts in Egypt: One near the Gulf of Suez, where the depth of the sea is only 25 fathoms to 40 fathoms, but suddenly increases to 300 fathoms and more further south in the Red Sea proper; the second on the main land of Sinai; and the third south of Kosseir on the coast of the Red Sea. Both the latter districts have so far been but little explored. Most of the oil comes from cretaceous sands, limestones and shales.

British and American Mining Methods.

Some of the reasons which render futile a direct comparison between the coal production per man employed in the collieries of the United States with the corresponding figure for the British miner were given in a lecture delivered at the Institute of Marine Engineers on Tuesday last by Mr. J. H. Anderson. Most of our thick seams, he points out, are practically exhausted, while those in the United States are so numerous that only the best and thickest need be worked. Even in these, about half of the coal is left in place to support the roof, so that but little timbering is required, whereas in most British mines the extraction amounts to about 90 per cent., and the cost of timbering, in several instances, is over 3*s.* per ton of coal raised. British mines are, of course, much deeper, on the average, than those in America, very few of which exceed a depth of 500 ft., while some of the mines in this country are 3,000 ft. deep. This obviously increases the cost of winning the coal and the difficulty of pumping and ventilating the mine; the higher temperatures encountered in deeper mines also tend to reduce output. Many American coal-fields, on the other hand, are worked by the open method and are simply quarries, the covering material being removed by large excavating machines and the exposed coal dug and loaded by smaller machines of the same class. In our thin seams much labour is involved in the upkeep of roads, and in the removal of material other than coal to give access to the latter. As is well known, machinery is used to a much larger extent in American mines than in British. Very little hand undercutting is done in the former, large undercutting, ripping and shearing machines being employed, some of which undercut the coal to a depth of 12 ft. In some cases machines are used to break down the coal with mechanical picks, collect it and deliver it directly into tubs. With such machines, employing two operatives, an average output of 21 tons per hour can be obtained for a whole week's working. In this country, although machines are used to some extent both for undercutting and conveying coal, even in thin seams, their general adoption is prevented by falls of the roof, alterations to floors, and faults in the geological strata which are of frequent occurrence in many pits, as well as by the prejudice of the British miner and his leaders. These considerations probably account very largely for the fact that the output of the American mines per man employed is about three times as great as that of the British mines. Actually they show, we think, that the conditions in the two countries differ to such an extent that a simple comparison between them is of small value. The point which really requires explanation is the decreased output per man here. For 19 years prior to 1908, the output of coal per man employed in the mines of this country was

never less than 280 tons per annum, and the labour cost never exceeded 6s. a ton, whereas, for 1919, the output was less than 210 tons per man and the wages cost more than 25s. a ton, according to figures given by Lord Weir in December last. Increased difficulties of working and permissible improvements in the miners' standard of living may account for some of this difference, but definite proof that restriction in output and absenteeism are not largely responsible for the change would be welcomed by all who have the industrial welfare of the country at heart.

Modern Developments in the British Brass Industry.

An interesting paper dealing with the above subject was presented by Mr. E. A. Smith, secretary of the British Non-Ferrous Metals Research Association, Birmingham, to the fortieth general meeting of the American Electrochemical Society, held at Lake Placid, Adirondacks, from September 29 to October 1. It bears a certain analogy to the presidential address delivered by Mr. Harold E. Yarrow to the Institution of Engineers and Shipbuilders in Scotland, to which we referred on page 574 *ante*, Mr. Smith, in his opening remarks, drawing attention to the preponderating part which scientific knowledge and methods play in the development of modern industry. His paper deals with every phase in the manufacture and treatment of the various brass alloys—melting, extrusion, hot pressing and forging, rolling, &c.—until their delivery for the numerous industrial uses to which they are put. It points out that manufacturers are to-day more fully appreciating the fundamental importance of a sound ingot as the primary step to the successful and economic manipulation of the material in subsequent operations. This, as our readers will remember, is a desideratum which has been constantly put forward by Dr. Rosenhain, the last public occasion being at the autumn meeting of the Institute of Metals, in Birmingham, with reference to the extrusion defect. In this connection, Mr. Smith endorses the use of the fireclay dozzle or feeder head; th› hot dozzle inserted at the top of the ingot mould acts as a small secondary crucible holding the metal in the liquid state at least sufficiently long o allow it to be drawn into the interior of the ingot, as required by the shrinkage cavity. In the matter of furnaces, Mr. Smith finds that whilst gas-fired ones offer several important advantages over coke-fired furnaces, it cannot be said that they are fully established for brass-melting generally, and the modified coke-fired crucible furnace is still the one most generally used for melting brass and other copper alloys. To his mind there would appear to be comparatively little scope in the British brass industry for electric furnaces of large capacity, in which the bulk of the electric brass melting is done in America. In the matter of the extrusion process, brass of the ordinary 60 : 40 composition is most suitable for strong extrusion work and is the most widely used alloy, being soft and easily extrudable; with an increase in the copper content the metal becomes harder and more difficult to extrude. A 600-ton press will satisfactorily deal with brass up to about 62 per cent., but larger presses are required for extruding metal of higher copper content. Brass of 60 : 40 composition has also been found in general practice to give the most satisfactory results in hot pressing and forging work. Mr. Smith gives in his paper several tables on the composition of brasses and of special alloys, on their mechanical tests, and deals with the utilisation of scrap and residues, and also with the aims and the work of the British Non-Ferrous Metals Research Association. In this latter respect, it is satisfactory to note that, although of quite recent formation, the Association has carried out a number of researches in non-ferrous metallurgy and is at the present time engaged on others in the same field. It invites manufacturers to submit their problems and to suggest researches. The problems will be gone into and the investigations carried out in a scientific manner, yielding data of the greatest value to the industry.

The Invention of the Aeroplane.

Although nothing can alter the fact that the Wright brothers were the first men actually to accomplish a sustained flight in a self-propelled aircraft of the heavier-than-air type, the view is widely held that Langley's failure, only a few weeks before the Wrights' successful attempt, in 1903, was due only to the failure of his launching apparatus. The latter opinion was, of course, greatly strengthened by the report, issued in 1915 by the Smithsonian Institution, stating that, in 1914, flights had been made in the original Langley machine at the Curtiss Aviation Field, Hammondsport, N.Y. Mr. Griffith Brewer, who carefully investigated these trials, both in 1914 and more recently, has, however, come to the conclusion that the Langley machine, in its original form, could never have flown, and that to render even a few short "hops" possible, certain fundamental modifications were necessarily made at Hammondsport. In his paper, read on Thursday, the 20th inst., before the Royal Aeronautical Society, Mr. Brewer states that, in the trials of the Langley machine in 1903, the wings collapsed through faults in design, and not because of the failure of the launching gear. The machine as used at Hammondsport, he says, had wings of different area, different camber and different aspect ratio, and the system of wing trussing was completely changed. The large keel surface of the original design was omitted from the Hammondsport machine, and several alterations to the engine, propellers and control system were also made. Further, according to Mr. Brewer, it was not until the Langley engine and twin propellers had been replaced by a Curtiss engine driving a single tractor screw of modern design, and the pilots' car of the original machine had been removed and replaced by a seat 14 ft. farther back and 3 ft. higher up than the seat in the original machine, that "hops" of more than 5 seconds' duration were made. Even the later flights appear, from the Smithsonian Report, to have consisted only of a series of longer "hops" at a height of about 30 ft. above water, and of a duration ranging from 20 seconds to 65 seconds, the machine descending on to the water at each lull in the wind. Other attempts to fly the machine were made until June, 1915, when they appear to have been abandoned after the collapse of the rear wings. The remains of the Langley machine, restored to its original form, were afterwards placed in the National Museum at Washington, with an inscription to the effect that it represented the first man-carrying aeroplane in the history of the world capable of sustained free flight; that it was invented, built and tested over the Potomac River by Samuel Pierpont Langley in 1903, and was successfully flown at Hammondsport, N.Y., on June 2, 1914. Mr. Brewer's contention is that this inscription is misleading and untrue, on account of the modifications found necessary at Hammondsport, no attempt having been made to fly the original Langley machine. These fundamental aerodynamic alterations, he says, were not mentioned in the report of the trials made to the Smithsonian Institution, and the latter body was therefore led to believe that Langley had succeeded, although Langley himself knew that he had honourably failed. From the evidence given in Mr. Brewer's paper it certainly would appear that his contention must be correct, and unless the statements made are capable of some altogether unexpected explanation, we feel confident that, in the interests of the history of the science, the Smithsonian Institution will take early steps to remove the erroneous impression created by its report of 1915.

LITERATURE.

Aeroplane Performance Calculations. By Harris Booth, B.A., Assoc.M.Inst.C.E. London: Chapman and Hall, Limited. [Price 21*s.* net.]

This work is an addition to Messrs. Chapman and Hall's long list in their "Directly Useful Technical Series." The author has written the book to supply the need of detailed literature on the subject. He points out that restricted information published up to the present time has scarcely touched the fringe of the subject, and hopes that his work will be found to be a comprehensive instrument for saving time, since aeroplane performance calculations can be very laborious if a clear and systematic method is not used.

Mr. Booth's book should help to supply these needs, and it is surprising how much useful material he has been able to accumulate under this title. The engineer should find many useful formulæ for his purpose in the second part of the work, and he is helped over any difficulty by reference to illustrative examples in Part III at the end of the book. The author has divided his treatise into three parts, viz., Part I, descriptive and theoretical; Part II, practical procedure; and Part III, illustrative examples. He hopes by this means to accumulate all the useful formulæ and data into one section and to place this in the middle because, as he says, at this position a book "is easier to keep lying open on the desk whilst in use." This may be so, but it is doubtful whether this advantage justifies sacrificing the natural sequence of the book. The first part, theoretical work, suffers badly in this way. Since curves, data, formulæ, &c., must be left to the second part, he has frequently to give future references, with the result that as many as 20 appear in the first 16 pages. The futility of such references can be seen, for example, on page 16, the opening of Chapter III, propeller performance curves, where, in the fourth line, reference is made to pages 100 and 101. Naturally we turn to these pages, but we find two sets of curves, one η_T plotted against J, and another η_E on the same base. These quantities are not defined until page 98, and therefore it is useless to refer on page 16 to these curves. On the whole Part I is weak, and many passages have of necessity to be repeated in Part II.

Chapters II and III are probably the weakest in the book. The first of these gives very little information. The author evidently intends to convey something useful with remarks such as "the properties of the wing with which we are chiefly concerned in performance calculations are k_l, the absolute lift coefficients, &c." These terms are not defined, however, throughout the book. No doubt many people engaged in aeronautical work know what is meant by absolute lift coefficient, but nevertheless there are probably more who do not, and amongst these many eminent men in the profession.

Chapter III is weak through two causes. In the first place, although the propeller and performance curves are treated for the first time in this chapter, no discussion is given of either. The chapter, in fact, confines its attention to a very special problem, viz., the effect of change of air density on the propeller performance curve, and assumes that the reader is well acquainted with the meaning of and the method of establishing these curves for ground level. In the second place, the author assumes that his reader has a thorough knowledge of the dimensional theory in its application to propellers. Almost at the beginning of the chapter he puts "Let the point on the curve at the altitude be so related to the point on the curve for standard density air that $V'/V = N'/N$. Then it follows from propeller theory that, &c." An elementary student could not possibly proceed beyond this point.

Chapters IV, Machine Performance, and V, Air Performance, are great improvements on the previous two. In the latter, however, we think that Mr. Booth's "Throttling Curves" are misnamed. The reader would certainly understand this section better if these curves were given their correct name, viz., constant V/ND curves. We would also like to suggest that instead of taking the trouble of drawing these curves on a sheet of celluloid, performance curves should be plotted on a V^3, base, in which case the constant V/ND curves become straight lines instead of cubics.

Chapters VI and VII are again fairly good. These deal with the performance of the machine when running along the ground, including the deck of a ship, and when moving over the surface of water. In the former chapter the author has inserted in one place much mathematics to prove the obvious. Equation (3), page 62, is a statement that a certain velocity is the sum of two others. This did not need establishing in the way given by the author, but could have been written down directly. On page 67 of the same chapter the reader is referred

back to a small sketch on page 41 to prove that a certain approximation is permissible. This sketch, in all probability is freehand, and therefore cannot be accepted as proof.

The next seven chapters compose the second part of the book. Each is a counterpart of the corresponding chapter in Part I. The formulæ and data contained therein should prove very useful to the practical man. The reader, however, should not take a footnote at the bottom of page 117 too seriously. This note applies to two formulæ, and says "as a matter of fact this formula is not quite useless, &c." No doubt the reader would wonder why "not quite useless" formulæ are given in a book which is a member of a "Directly-Useful Series," but we do not think the author means this note seriously. Very little adverse criticism can be levelled against Part II, excepting as to page 87, where the characteristics for five wing-sections are given, viz., R.A.F. 15, R.A.F. 16, No. 64, No. 214, R.A.F. 19. These figures are useless unless the reader knows the shapes of these sections. No doubt many are acquainted with R.A.F. 15 and R.A.F. 19, but it is doubtful whether many people know what is meant by No. 64 and No. 214.

Part III contains eight chapters of very useful illustrative examples. The first seven apply individually to the corresponding chapters in the other parts, and any difficulty experienced in the reading of these parts can be readily cleared up by reference to these end chapters. The last chapter works out completely a typical machine, and should prove very useful.

In conclusion we might say that "Aeroplane Performance Calculations" contains a wealth of good material for designers, but it is capable of being further developed and some of its data improved. The book has not been written up in a homogeneous manner; some parts receive full treatment but others very scanty. We are afraid that Mr. Booth has contented himself with publishing his first draft, and it is strongly felt that had he critically read his work from the point of view of his reader, inserting passages to bring into due prominence all underlying principles, he would have produced a good readable book.

The Human Factor in Business. By B. Seebohm Rowntree. London: Longmans, Green and Co. 1921. [Price 6s. net.]

Few men are entitled to a more respectful hearing on the subject of the amelioration of the conditions of labour than the author of this book. Not as a faddist or sentimentalist, but from a keen sense of duty, he has laboured long and strenuously to improve the worker's status, to promote efficiency of production, and to ensure industrial peace. No man could be freer from the charge of Pharisaism, and we have no doubt he would willingly have been spared this advertisement of what has been accomplished at the Cocoa Works of York, were he not convinced that it was his duty to throw his experience into the common stock of knowledge, in order to advance the cause that aims at creating more harmonious conditions between employers and their staff, and at reducing the industrial unrest which is paralysing the trade of the nation.

Many employers are now willing to admit their responsibility for the conditions under which the people in their employment pass the working hours of their lives. They not only accept legislative interference to enforce provision for the comfort of the workers, but anticipate the necessary measures. Economical management and the proper ordering of industry are receiving attention, which cannot but be accompanied by happy results. The recognition of economic justice has become more than a pious aspiration it has entered into the region of practical politics and the problem confronting capital and labour, the problem that statesmen and labour leaders have to solve, is to devise and organise the application of machinery that can be applied through the ascertained operations of economic cause and effect to the concrete facts of industrial life.

No one knows better than the author that the question is far larger than the adoption of methods which may succeed in smoothing over existing disagreements, and reducing the losses due to constant friction, but the possibilities of a single firm are limited. Consequently, the author limits himself to showing how wages may be regulated so that all employees can live in reasonable comfort, while admitting of a careful adjustment of wages above the minimum, according to the value of the service rendered. Next a plan is indicated by which the worker is freed from the dread of economic insecurity due to unemployment. The plan is costly, but the waste of energy and efficiency occasioned by the irritation of a grievance is often greater than the cost of removing it. Care of the operatives, health, provision for recreation and welfare work generally, are discussed thoroughly, and the burning question of giving labour a share in the control of industry is freely and dispassionately considered. The author recognises that no very substantial share in the control of business can be given to workers, unless they are directly interested in the prosperity and financial stability of the enterprise with which they are associated. The conclusion of Mr. Rowntree is that some method of attaining this end must be devised, if we are to establish industrial peace.

It is to be presumed that the author's schemes, liberally conceived and admirably put into execution, have secured harmony in the Cocoa Works at York, and that the demon of unrest has been effectually laid by the removal of grievances. For with this experience behind him, Mr. Rowntree declares distinctly that industrial peace can be had, if employers are willing to pay the price. The alternatives of strikes, lock-outs and diminished production is not pleasant to face, but it is possible that the demands of labour may become so exorbitant that industries can no longer be carried on. This is the avowed aim of many, who believe, or affect to believe, that the capitalistic system is responsible for all the evils of the past and all the dissension of the present. The efforts of many are directed not to effect improvement, but to promote destruction, and this determination renders more difficult the task of those who are working to defeat the wanton and reckless purpose of the evil-intentioned, and makes the more necessary and welcome this detailed account of what is being effected by enlightened and well-disposed employers of labour.

BOOKS RECEIVED.

Transactions of the American Society of Civil Engineers. Vol. LXXXIII, 1919–20. New York: Published by the Society.

Gasoline and other Motor Fuels. By Carleton Ellis and Joseph V. Meigs. London: Constable and Co., Limited. [Price 60s. net.]

Dock and Lock Machinery. A Technical Manual. By W. Henby Hunter, M.Inst.C.E., M.Am.Soc.C.E. London: Constable and Co., Limited. [Price 17s. net.]

Aggregation and Flow of Solids. Being the Records of an Experimental Study of the Micro-Structure and Physical Properties of Solids in Various States of Aggregation, 1900–1921. By Sir George Beilby, F.R.S. London: Macmillan and Co., Limited. [Price 20s. net.]

Thermodynamics. By J. E. Emswiler. First edition. New York and London: McGraw-Hill Book Company, Inc. [Price 18s. net.]

Department of Scientific and Industrial Research. Report of the Food Investigation Board for the Year 1920. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 1s. net.]

Der Brückenbau. Handbuch der Ingenieurwissenschaften II Teil. Erster Band. Die Brücken im Allgemeinen. Massive Brücken in Stein. Beton und Eisenbeton. Herstellung und Unterhaltung der Steinernen Bogenbrücken. Von Dr. Ing. Th. Landsberg und M. Foerster, Th. Landsberg, G. Mehrtens. Fifth edition. Leipzig: Wilhelm Engelmann. [Price 45 marks plus 100 per cent.]

American Tool Making and Interchangeable Manufacturing. Design, Construction, Use and Installation. By Joseph V. Woodworth. London: Page and Co. [Price 25s. net.]

The Westinghouse E.-T. Air-Brake Instruction Pocket Book. By W. W. Wood. London: Page and Co. [Price 12s. 6d. net.]

Air-Brake Catechism. Including the E.-T. Locomotive Equipment, the "K" Triple Valve for Freight Service, &c. By Robert H. Blackall. Twenty-eighth edition. London: Page and Co. [Price 12s. 6d. net.]

See- und Seehafenbau. By Von H. Proetel. Berlin: Julius Springer. [Price 40 marks.]

British Labour. Replacement and Conciliation, 1914–21. Being the Result of Conferences and Investigations by Committees of Section F of the British Association. Part I. *On Replacement.* Co-ordinated and revised by Miss L. Grier and Miss A. Ashley, M.A. Part II. *On Conciliation.* Edited by A. W. Kirkaldy, M.A. London: Sir Isaac Pitman and Sons, Limited. [Price 10s. 6d. net.]

THE TRIALS OF THE GERMAN ARMOUR PLATES.

In our issue of September 16 last (page 419 *ante*) we published the results of tests made by the Admiralty on the armour plates, of various thicknesses, taken from the German battleship Baden. This ship, it will be remembered, was surrendered under the Peace Treaty, and a full description of it was given in a paper read before the Institution of Naval Architects at their annual meeting last year, and published in full in Engineering of March 18, 1921, page 337. It may be said at the outset that only in the case of the thinnest armour, namely, that of 80 lb. per square inch, did the German armour come up to the quality of the British armour. On page 604 and in the opposite page we reproduce photographs of the front and rear of each of the plates, beginning with the heaviest, namely, that of 560 lb. per square inch. Of the armour tested this probably came nearest to the British standard. The photographs are very instructive, and show that the plates were very considerably punished by the projectiles used; in many instances the shot penetrated the plate. There is no need to enter into particulars, as the Admiralty are not publishing the details of the attack. We publish a table, setting forth the results of the trials, which indicates the superiority of the British armour plate in all but one instance. In the table the average limiting velocity of penetration for British plates is taken to be 1,000 ft. per second in each case, and the fourth column shows the comparative figures for German plates. The shells used at these trials were of similar mark and quality to those used in testing British plates of the same thickness.

Thickness of Plate in Lb. per Sq. In. Lb.	Index No. Representing Limiting Velocity of Penetration. British.	German.
560 K.C. armour (Figs. 1 and 2)	1,000	915
480 K.C. armour (Figs. 3 and 4)	1,000	Less than 835*
400 K.C. armour (Figs. 5 and 6)	1,000	Less than 895*
320 K.C. armour (Figs. 9 and 10)	1,000	940
200 turret-roof plate (Figs. 7 and 8)	1,000	Less than 935*
160 turret-roof plate (Figs. 11 and 12)	1,000	Less than 955*
80 bulkhead plate (Figs. 13 and 14)	1,000	1,000

* In these cases, owing to the limited space available for attack, the velocities could not be taken low enough to determine the limiting velocity, the shells, at the velocities indicated by the index figures, passing on practically undamaged, except in the case of the 200-lb. roof plate.

China's Petroleum Wells.—A recent investigation shows that China possesses petroleum wells in the following provinces:—Chihli, 22; Kirin, 2; Yunnan, 17; Kiangsu, 5; Hunan, 4; Szechwan, 3; Kwangtung, 1; Fengtien, 4; Kweichow, 13; Shensi, 8; Kwangsi, 4; Kiangsi, 4; Hupeh, 2. The total throughout the country is 91 wells, the best of which are in Chihli, Kweichow, Yunnan and Szechwan.

Specifications for Air-Break Knife Switches and Laminated Brush Switches, and Air-Break Circuit Breakers.—Two standard specifications have just been issued regarding air-break knife switches and laminated brush switches, and air-break circuit breakers, all for pressure not exceeding 600 volts, by the British Engineering Standards Association. A comprehensive research is being undertaken by the Electrical Research Association, on the rupturing capacity for large sizes, and safety of insulation, and when the results of this are available it may be possible to extend the specifications. The present specifications do not include switches and circuit breakers for use with series motors, circuits of high inductance or traction circuits, all of which may require a higher breaking capacity than is specified therein. A distinction between an isolating switch, a switch and a circuit breaker has been laid down as follows: An isolating switch is intended only for interrupting the circuit when there is no load-current; a switch is suitable for breaking a load-current; and a circuit breaker is suitable for interrupting a short circuit. A number of terms used in modern switch-gear practice have been defined, and a series of standard sizes has been included. The tests have been divided into two categories, i.e., those carried out on every switch or circuit breaker and those which are carried out only on a switch or circuit breaker of a type. The issue of these specifications marks a distinct step forward towards the simplification of switch gear generally, and is the result of concerted action of the interested electrical associations, Government Departments, the Institution of Electrical Engineers, the Electricity Commissioners and the National Physical Laboratory. The specifications are obtainable from the Association, 28, Victoria-street, S.W. 1, at a cost each of 1s. net, post free 1s. 2d., No. 109 dealing with knife switches and laminated brush switches, and No. 110 with circuit breakers.

RESULTS OF TESTS OF GERMAN ARMOUR PLATES.

(For Description, see opposite Page.)

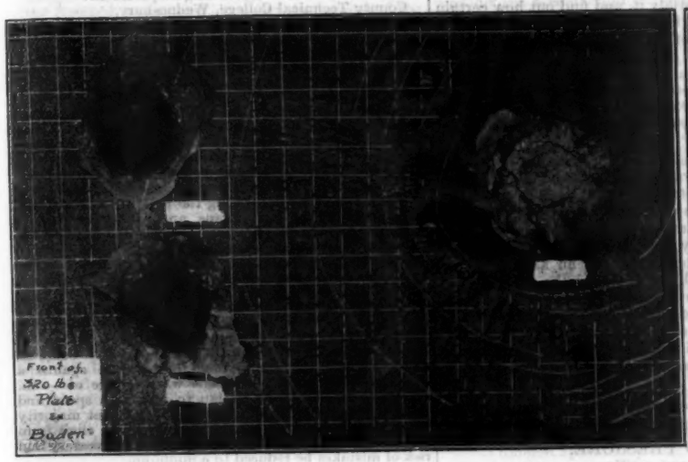

FIG. 9.

FIG. 10.

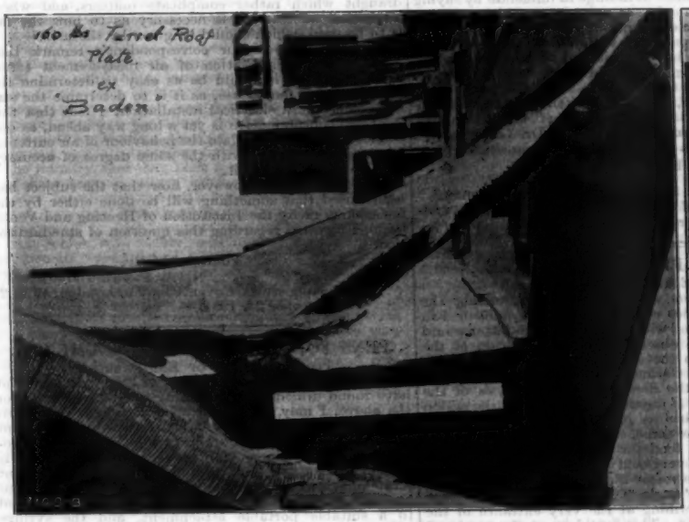

FIG. 11.

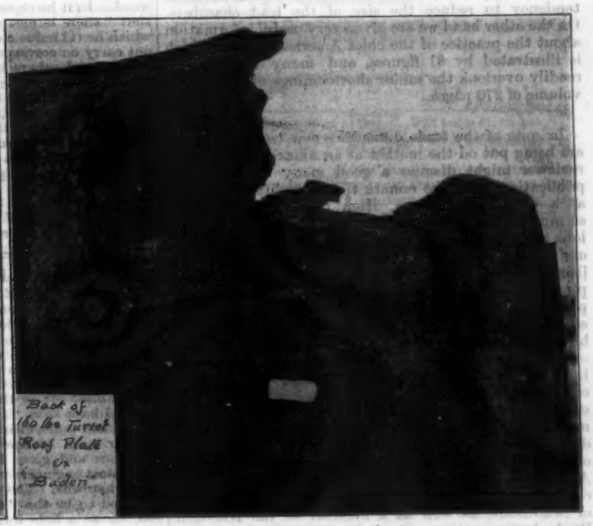

FIG. 12.

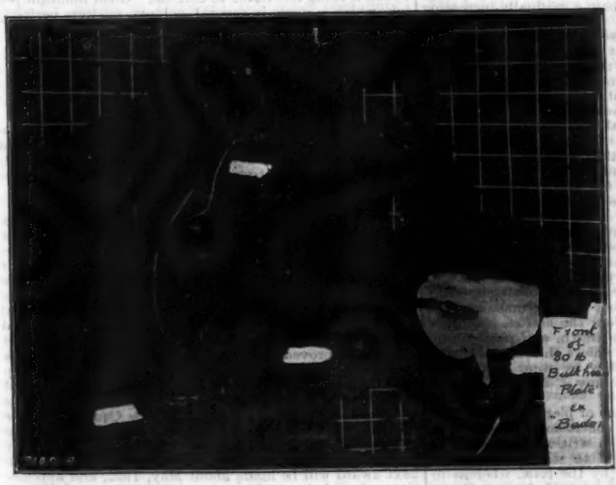

FIG. 13.

FIG. 14.

NOTES ON NEW BOOKS.

Whilst it would be difficult to assign a definite date to the first manufacture of sulphuric acid, the claims of Geber, of A.D. 960, being somewhat doubtful, we may accept it that John Harrison started the first American sulphuric acid works in Philadelphia in 1793. Everybody knows that this industry developed there and assumed enormous dimensions during the war. In a book like "*American Sulphuric Acid Practice*," written by Philip de Wolf and E. L. Larison, of the Anaconda Copper Mining Company, Montana [McGraw-Hill Book Company, New York and London, 21*s.* net], one would naturally expect to find some definite figures as to production under the heading "Development and Status" of the first chapter. But we have no figures beyond the statement that one war-plant, completed in 1916, produced 250,000 tons of fuming acid per year, whilst the production of the whole country had amounted to 49,000 tons in 1914. That is partly excused by the statement that the last statistics of the Department of Commerce referred to the year 1915. Further on, Lunge is quoted as saying: "There are 270 sulphuric acid works in the United States to-day, of which 44 employ chemists." The "to-day" is not explained, and while the authors are undoubtedly competent chemists and write instructively for the practical man, they are occasionally also careless and disappoint the reader by omissions. Words and names are misspelt, *e.g.*, diluant, Wessel instead of Messel, Kneitsche instead of Knietsch, not to mention the disregard of modified vowels; we read that "impurities in the gas (SO_2 is meant) are both mechanical and chemical, and each class of treatment is necessary"; the incomplete index does not mention Kessler concentrators, and Gaillard towers are not referred to at all; very little is said about the much-discussed tendency to reduce the size of the lead chambers. On the other hand we are given very useful information about the practice of the chief American works, which is illustrated by 81 figures, and many readers will readily overlook the minor shortcomings of the octavo volume of 270 pages.

In spite of the trade difficulties new technical books are being put on the market at an amazing rate. The reviewer might dismiss a good many of these new publications with the remark that very little is offered at a very high charge. High prices have, indeed, so much become the rule that one almost hesitates to look at an inexpensive volume. Books like "*Industrial and Power Alcohol*," by Dr. R. C. Farmer, F.I.C. [Sir Isaac Pitman and Sons, 2*s.* 6*d.* net], form a most pleasing exception. The engineer might fear that a publication of 110 16 octavo pages would deal with the alcohol problem on too general lines to be of use to him. But this little book is really instructive throughout, and the adequate references to the most recent literature will facilitate further study. Dr. Farmer comes with high credentials, and he takes the pains and care of the young, unknown author—a point worth mentioning; for some well-known men now appear to dictate books in their leisure hours. Dr. Farmer was one of the principal research chemists at the Royal Arsenal, Woolwich, and became, during the war, chief chemist to the Explosives Department of the Ministry of Munitions, as well as a member of the Nitrogen Products Committee and of the Chemical Committee of the Munition-Inventions Department. He discusses the problems of the sources, production and denaturation of alcohol, its manifold applications, and its use as fuel, and the economical aspects and excise rules, in a manner which the general reader will understand and which the engineer will appreciate. He has followed up the development of power alcohol; his statistics refer to our days, and he knows what is essential and likely to assume practical importance. We warmly recommend his "Industrial and Power Alcohol."

A thoroughly practical little manual on the art of the smith, such as the "*Handbook of Practical Smithing and Forging*," by Thomas Moore (London: E. and F. N. Spon, Limited, price 7*s.* 6*d.* net), should appeal to a large circle of readers, for smiths' work not being of a nature to lend itself to theoretical discussion is a branch of engineering which is almost entirely disregarded in colleges and technical schools. The neglect of any proper knowledge of the work of the smith is a defect in engineering education, and a little practical experience of it would teach a student facts about the nature of iron and steel which he can never learn from testing machines or from micro-photographs. It is, moreover, one of the most interesting of the crafts, and like patternmaking, it calls for a power of creating new forms from raw material which is not demanded in the other mechanical trades. The book which we are now noticing can be cordially recommended. The author modestly claims that it "does not pretend to be a learned and classical treatise, such as would be expected from some great professor, but simply a plain straightforward statement of a practical smith." We only wish that more "great professors" could write as well and clearly and from so exact knowledge of their subjects as Mr. Moore. The book cannot fail to interest not only learners, but also experienced smiths, and if mechanical draughtsmen and designers would study it, and find out how certain forgings have to be made, they would think twice before sending some of their designs into the shops.

The necessity for issuing elementary volumes at a low price to suit the pockets of students explains why the big subject of "*Iron Foundry Practice*" is treated in a volume of 264 pages by George J. Pitt (London: Cassell and Co., Ltd., price 6*s.* net). A criticism to which the volume is open is the paucity of illustrations, which only number 65, and generally these lack detail, being too skeleton-like in character. It is not possible to convey a clear impression by mere verbal descriptions of many of the matters treated to one who is not already familiar with foundry details, notwithstanding that the descriptions are lucid, and by an author who is familiar with the subject of which he treats. The work of the iron foundry is dealt with in 21 chapters. The great divisions are passed in review, but of course examples of actual moulding are nearly non-existent. The book is one of principles and leading facts, stated clearly and concisely, and the student may read it with interest and profit.

"STRESSES IN SHIPS' PLATING DUE TO FLUID PRESSURE."

To the Editor of Engineering.

Sir,—In the letter on this subject appearing in your issue of the 21st inst., Dr. Laws contributes his final word. In it he chooses to indulge in innuendo by saying that "there is *now only one point* in my (his) paper on which he (I) holds a difference of view." I would rather not carry on correspondence with a view to clearing up what I and others have considered to be a misleading statement when suggestive and inaccurate statements of this kind are put forward.

I must thank you, Sir, for permitting me to interpret Dr. Laws' "quantitative" "diagram" and to remove the wrong impressions created by it. Dr. Laws has yet to appreciate that a diagram may be quantitatively so inaccurate as to be qualitatively misleading.

Yours faithfully,
T. B. Abell.

The University of Liverpool, School of Naval Architecture, October 24, 1921.

"ROTARY PIERCING MACHINES."

To the Editor of Engineering.

Sir,—I have been very interested in reading the articles by Mr. Davies on Rotary Piercers published in your recent issues, and within the limits of a letter would like to make a few observations. The portion of the articles dealing with the action of these machines is a translation from a German source, acknowledged by Mr. Davies. It is the first attempted analysis of the action I have seen. If anything else exists on the action of inclined rolls either as piercers or reelers I should like to learn of the same. Although the analysis is ingenious and gives food for thought it will, I think, leave most engineers very cold as an explanation of what really happens. The *raison d'etre* of the hole formation is stated to be the "angle of twist." Fig. 14, on page 495, shows a hole forming at the very entrance of the billet into the piercer. This would be so if equation 8 were a true mathematical statement of the conditions controlling the hole formation. Fig. 17 (0, 1, 2, 3, 4, 5, 6) are pretty geometrical figures but unconvincing, for there actually is no hole where a gradually-increasing hole is shown.

Watching a piercer one can see no hole until the billet has passed the central point M or neck. The hole probably is "formed" before this point, i.e., the inside fibres are parted but there is no hole as such. A little thought given to Fig. 14 will show its unreliability. Take the thin shell between sections 5 and 6. Would this maintain the pressure on the roll surfaces necessary to give the tangential frictional force to twist the billet?

The analysis assumes the billet to remain round while passing into the neck and while at the neck. Figs. 8 and 9*a*, on page 398, assume the billet to be round at $d\,x$ and $d\,z$. Is this so? I have watched several piercers, and the billet is undoubtedly oval at the neck. This ovalling does not eliminate but does reduce the "angle of twist." The twisting and its effects are unfortunately often very evident in a rotary pierced billet. It is difficult to conceive a rotary piercer which would act without twisting the billet relatively to itself. The twisting is a necessary evil, but the German analysis makes it into a virtue to explain the action. Another thing I wish to mention. Any smith, and particularly one used to big hammer work, knows that he can make the inside of a round bar hollow by rotating the bar under the hammer. Is there any "angle of twist" in this case?

Mr. Davies from his experience of piercers knows that the German analysis leads to conclusions far removed from observed phenomena, for in writing about Fig. 14 he states "the hollow is shown to start immediately the end of the billet is gripped by the rolls, whereas in the written opinion it commences much later and the breaking away from the centre is less gradual." We are indebted to Mr. Davies for his ably written articles and also to Major Royds. These gentlemen have done good service by bringing to our notice the articles written in *Stahl und Eisen*, but I think a satisfactory explanation of piercer action has yet to be published.

Yours faithfully,
W. R. Parsonage, B.Sc., Eng.Lond., M.I.Mech.E.,
Head of Engineering Department.

County Technical College, Wednesbury,
October 25, 1921.

STANDARDISATION OF FAN CAPACITIES.

To the Editor of Engineering.

Sir,—The letter by "Exporter" under above heading, in your current number, draws attention to an important point in connection with the paper read on the 11th inst. before the Institution of Heating and Ventilating Engineers. As your correspondent rightly points out, it is particularly important as regards export business that there should be uniformity or standardisation of the terms used for expressing the pressure or resistance against which the fan or fans are to operate, as, of course, it is impossible to refer the matter back to the prospective purchaser or ask him to send plans of the proposed application showing air ducts, &c.

Whether it is preferable to give the fan performance in static or total water gauge is a debatable point. The custom in the past with the majority of British fan makers has been to give static water gauge. The writer would suggest the following formula when asking for fan quotations: Required a fan to deal with — cub. ft. per minute of air at — deg. temperature against a maintained resistance, or static water gauge of — in. size of inlet and outlet of fan to be given, speed and brake horse-power on fan shaft. In the great majority of cases the use of the above formula would elicit from the fan maker all the information which is necessary and risk of mistakes be reduced to a minimum.

The writer, however, agrees with the author of the paper under discussion that there are applications of fans such as in connection with the various forms of mechanical draught which rather complicate matters, and where additional information is necessary as to how the fan is to be used, which should be given by the user.

With regard to your correspondent's remark that perhaps if standardisation of air measurement terms was arrived at, it would be as easy to determine the correct size of fan to use, as it is to determine the size of dynamo in an electrical installation, I fear that this desirable consummation is yet a long way ahead, as one cannot at present calculate the behaviour of air currents, frictional losses, &c., with the same degree of accuracy as in an electrical circuit.

It is to be hoped, however, now that the subject has been raised that something will be done either by the fan makers or by the Institution of Heating and Ventilating Engineers regarding this question of standardisation.

Yours faithfully,
A. Fleming Browne.

33, King-street, Covent Garden, London, W.C. 2,
October 24, 1921.

PENS FOR RECORDING INSTRUMENTS.

To the Editor of Engineering.

Sir,—For the benefit of any of your readers who have found difficulty in obtaining satisfactory pens for the above, I may say I find after a number of experiments that very reliable pens can be easily made from the needles of an hypodermic syringe. These are procurable of any degree of fineness, and if the point is ground off square, and carefully rounded, to prevent scratching, will draw a beautifully even and continuous line. The small plated fitting or socket may be soldered to a suitable portable attachment, and the syringe proper used to fill the pens or to clean them after use.

The socket alone holds sufficient ink for quite a long record. Nickel needles should be selected in preference to steel, being less liable to corrode. Good fountain-pen ink, which is made in several colours, answers perfectly where a number of simultaneous records are required.

Yours truly,
A. T. Turner.

Nestleton, King's-road, Knock, County Down,
October 20, 1921.

Corporation of Lloyd's.—Sir Edward Fitzmaurice Inglefield, K.B.E., R.N., who for sixteen years has held the position of secretary of the Corporation of Lloyd's, has been compelled to tender his resignation for reasons of health.

The "Archibald Dawnay" Scholarship in Civil Engineering.—The London County Council state that one "Archibald Dawnay" scholarship in civil engineering, from moneys bequeathed to the Council by Sir Archibald Dawnay, will be awarded annually, tenable as a rule for three years at the civil engineering course at the Battersea Polytechnic, the Finsbury Technical College, or the Northampton Polytechnic. Additional institutions at which the scholarships may be held may be approved in future as additional scholarships are inaugurated. At the present time the scholarship is of the value of 110*l.* a year, the student being required to pay for his tuition, books, &c. The general conditions of award are similar to those for the Council's senior science scholarships, candidates' parents must be ordinarily resident in the County of London, and their income must not generally exceed 750*l.* a year. The next award will be made about May, 1922, and applications should be addressed to the Education Officer (T2a), New County Hall, S.E. 1.

RESEARCHES ON ALUMINIUM ALLOYS.

*Summary of the Eleventh Report to the Alloys Research Committee: On Some Alloys of Aluminium. (Light Alloys.)**

By WALTER ROSENHAIN, B.A., D.Sc., F.R.S., SYDNEY L. ARCHBUTT, F.I.C., and D. HANSON, D.Sc., from the National Physical Laboratory, Teddington, where the Research was carried out under the auspices of the Alloys Research Committee.

SECTION I.

Introduction.—The present summary gives a brief account of the principal contents of the Eleventh Report to the Alloys Research Committee. That report, comprising 256 pages, 92 figures in the text and 24 plates, is itself a greatly condensed record of researches covering a period of eight years since the publication of the Tenth Report.

Owing to the length of time covered, the effect of war conditions, and other developments leading to the employment of greater resources than those used in connection with earlier reports, the results and data recorded are so numerous that representation by graphs and diagrams has been extensively employed. Here it is only possible to refer briefly to the more important features.

In presenting the report, the authors point out that the researches are the result of the organised work of practically the whole staff of the Metallurgical Department of the National Physical Laboratory, and that they have received important help from colleagues in other departments of the Laboratory, and from a number of firms and gentlemen connected with the industry. Fully detailed acknowledgments are made.

SECTION II; CAST ALLOYS.

II. (*a*) *Alloys for Use at Ordinary Temperatures.*—In continuation of the researches described in the Tenth Report to the Alloys Research Committee, the properties of the alloys of copper, zinc and aluminium have been further examined. A considerable number of castings, both sand and chill, have been made and tested. Tensile strengths up to 19 tons per square inch in the case of sand castings and 20 tons per square inch in the case of chill castings have been obtained with alloys containing 2 per cent. to 3 per cent. copper and about 25 per cent. to 30 per cent. zinc, whereas in alloys containing about 15 per cent. of zinc, tensile strengths of about 14 tons per square inch are recorded. For practical purposes, however, the alloys rich in zinc have certain undesirable properties; they are very weak and brittle when hot, and are therefore liable to accidental injury in the foundry, and they have a relatively high density. For these reasons, alloys having a rather lower zinc content, in combination with 2 per cent. to 3 per cent. copper, have been found most generally useful for castings not exposed to high temperatures. The best known is that which was widely used during the war under the aircraft specification "L5." This alloy contains from 12½ per cent. to 14½ per cent. of zinc, and from 2½ per cent. to 3 per cent. of copper. A freshly-cast chill test-bar is specified to show a tensile strength of not less than 11 tons per square inch, and an elongation of 4 per cent. on 2 in., requirements which are very moderate, and have often been exceeded by the authors. The strength of such castings, however, increases considerably on ageing.

The density of alloys of this system has been determined in a large number of cases. In alloys containing up to 3 per cent. of copper, the density varies from approximately 2·8 in an alloy containing 5 per cent. of zinc to 3·2 in an alloy containing 25 per cent. of zinc. Castings of "L5" have a density of approximately 3, the differences between sand and chill castings being inappreciable. Other alloys, arising out of investigations described in Sections II (*b*) and II (*c*), are also suitable for use at ordinary temperatures; they are described in the next two sections.

II. (*b*) *Cast Alloys for Use at High Temperatures.*—The advantages to be gained from the use of aluminium alloys for pistons in aeroplane and other high duty internal-combustion engines, having been demonstrated in practical trial as well as indicated by theoretical considerations, the problem of finding the most suitable casting alloy for this purpose became of considerable importance. A very large amount of attention has been devoted to this subject.

In the first place it became necessary to ascertain the strength of various alloys at high temperatures in the manner which has already been described (see Eighth, Ninth and Tenth Reports to the Alloys Research Committee).

The results of tests on aluminium-zinc alloys show that the tensile strength falls off very rapidly as the temperature increases. Further tests at high temperatures have shown that the ternary alloys of copper, zinc and aluminium behave in a similar manner. In the case of the alloy "L5," it is found that, starting with a tensile strength of about 13·5 tons per square inch at normal temperature, the strength falls off at 250 deg. C. to little more than 4 tons, and at 350 deg. C. to about 1·5 tons per square inch. For this reason, alloys containing zinc have been abandoned for use where high temperatures are involved.

The behaviour of certain binary copper-aluminium alloys in the extrusion press had suggested that they possess considerable strength at high temperatures, and an extensive series of tensile tests was therefore undertaken on alloys belonging to this system. Alloys containing 6 per cent. to 14 per cent. of copper have approximately the same strength (7 tons per square inch) at 250 deg. C.; at somewhat higher temperatures, however, the alloys containing 12 per cent. to 14 per cent. of copper are distinctly better than those containing lower proportions. The 12 per cent. alloy, for example, at 350 deg. C. possesses a tensile strength of about 4·6 tons per square inch as compared with 3·4 tons per square inch for the 8 per cent. alloy. The alloy containing 12 per cent. of copper has been extensively used for the manufacture of light alloy pistons, and is well known by its Air Board specification number "L8."

Efforts were made to improve the properties of the simple copper aluminium alloys by the addition of other elements, and it was found that manganese in small proportions has a profound influence on their strength. In alloys containing both 8 per cent. and 14 per cent. copper, both chill and sand cast, it was found that the addition of 1 per cent. of manganese causes an actual increase in tensile strength with rising temperature up 250 deg. C.; at this point the tensile strength is approximately 1 ton per square inch greater than at normal temperatures. Above 250 deg. C. the strength decreases at much the same rate as that of the pure copper alloys, but owing to the initial rise, the strength at 350 deg. C. is still very much better. In the 14 per cent. copper alloy containing 1 per cent. manganese, the strength rises from 9 tons, as chill cast, to 10 tons per square inch, when tested at 250 deg. C., while at 350 deg. C., 6·4 tons per square inch are still obtained. In the case of sand castings the results at normal temperatures and at 250 deg. C. are approximately 1 ton per square inch less than chill castings, but at 350 deg. C. this difference has practically disappeared.

This effect of manganese was so striking that it was investigated more closely, with a view to ascertaining if the addition of greater or smaller amounts would produce better results. It was, however, found that the best results were obtained with 1 per cent. manganese, and that the effect of this element was less if the content differed appreciably from this value.

For various reasons the 14 copper, 1 manganese alloy was not regarded as the final solution of the piston alloy problem, and other alloys were investigated. Additions of iron, molybdenum, tungsten, chromium, vanadium and other elements to copper aluminium alloys were tried without better results. In the majority of these alloys it was found that a comparatively small addition of the second element made the metal very difficult to cast. More promising results were obtained in the case of nickel-copper-aluminium alloys, which were at a later date further improved by the addition of small amounts of magnesium. The first result of adding nickel is a marked increase in the tensile strength, both in the cold and at 250 deg. C. For example, the strength of the 12 per cent. copper alloy at normal temperature is raised by nearly 2 tons by the addition of 3 per cent. nickel, and by over 3 tons per square inch at a temperature of 250 deg. C., at which a tensile strength of 10 tons per square inch is obtained. At 350 deg. C., however, the tensile strength is still rather low, namely: 5·3 tons, about 1 ton per square inch lower than that of the "14/1" alloy. The addition of small amounts of magnesium to alloys containing both copper and nickel led to further improvement. In one case, in an alloy containing 8 per cent. copper, 2 per cent. nickel, and 1 per cent. magnesium, a tensile strength of nearly 13 tons was observed, as compared with 8 tons per square inch in the alloy having the same copper and nickel content without magnesium. Ultimately it was found that the copper content of these alloys could be safely reduced with considerable advantage both to lightness and to thermal conductivity, and an alloy containing 4 per cent. copper, 2 per cent. nickel and 1½ per cent. magnesium, mentioned elsewhere in this report as alloy "Y," was adopted. This alloy, in the form of 1-in. chill castings, possesses a tensile strength of 13 tons per square inch, at normal temperature, which only falls to a little over 11 tons per square inch at 250 deg. C., to 8 tons per square inch at 300 deg. C. and to 5 tons per square inch at 350 deg. C. An interesting and important observation in connection with this alloy is that the elongation at 350 deg. C. is fairly large (about 15 per cent.) —this led the authors to try forging and rolling of the material with very successful results (Section III (*c*)).

Further experiments showed that the nickel and magnesium contents of this alloy might be varied within reasonable limits without very harmful effects, but the composition originally arrived at, as quoted above, is the best of the materials tested.

Casting of the Alloys.—In addition to the ordinary precautions which have to be taken in making complicated castings, in order to avoid such defects as "drawing," evolution of gas, &c., some special points may be mentioned. In the case of alloy "Y," and other aluminium alloys containing magnesium, the method of adding this latter element is found to be of importance. In the authors' experience, it has been found best to add the magnesium in the form of pure metal cut into fairly large pieces, and to push these rapidly under the surface of the molten aluminium, so that they can dissolve without coming into contact with the air. The addition should be made immediately before the metal is poured into the mould. Some care is also necessary in making additions of nickel. Pure nickel does not readily dissolve in aluminium, and the authors find it best to prepare a "hardener" or rich alloy, containing 20 per cent. of nickel, and to add this in the requisite quantity to molten aluminium. Hardeners richer in nickel are to be avoided on account of their high melting-points.

Thermal Conductivity.—The gain in efficiency in internal combustion engines which results from the use of light alloy pistons is due, not so much to any small saving in weight of the reciprocating parts, as to the greater heat-conducting power of the aluminium alloy. Careful determinations of the thermal conductivities of the different alloys were therefore made during the progress of the research. The values obtained for the various alloys do not, as a rule, differ to any large extent, although the "14/1" alloy, in the "as cast" condition, is a notable exception to this rule. In this latter case values of 0·25 to 0·27 were found in castings tested at 100 deg. C. as compared with values of 0·35 to 0·39 in the case of most of the other alloys, and with 0·50 in the case of pure aluminium. The values found for alloy "Y" are appreciably higher, 0·37 and 0·40 being obtained in the case of chill castings tested at 100 deg. C. and 300 deg. C. respectively. Annealing at 450 deg. C. has a beneficial effect on practically all the alloys, this effect being slight except in the case of the "14/1" alloy, which, after this treatment, is little inferior to any of the others. Comparison tests made on samples of cast-iron gave values of 0·10 to 0·12 under similar conditions of heat treatment and testing.

II (*c*) *Heat-Treatment of Castings.*—Considerable improvement in the mechanical properties of cast aluminium alloys has been obtained by suitable heat-treatment. Practically all castings possess inequalities of composition due to micro-segregation during solidification. In the case of the simple copper aluminium alloys, for example, castings containing as little as 2 per cent. of copper normally contain free particles of the compound $CuAl_2$, whereas a saturated solid solution of this compound in aluminium contains nearly 5 per cent. of copper. By annealing at about 500 deg. C., the undissolved $CuAl_2$ can be brought into solid solution in alloys containing up to about 4½ per cent. of copper, with considerable improvement in the mechanical properties; for example, the strength of the alloy containing 2 per cent. copper was found to increase from 8 tons per square inch "as cast" to 10 tons per square inch after annealing, and that of the alloy containing 4½ per cent. of copper from 9½ tons to 15 tons per square inch. At the same time a remarkable increase in elongation is produced.

TABLE I.—*Alloy "Y." 1-In. Diameter Chills.*

Treatment.	Ultimate Stress. Tons per Square Inch.	
	15° C.	250 °C.
As cast	12·6	10·5
Tempered 48 hours at 250 deg. C.	9·8	8·7
Heat-Treated.		
(1) Open Muffle :—		
6 hours 480 deg. C. quenched and aged	14·9	11·3
6 hours 480 deg. C. tempered 48 hours at 250 deg. C.	13·4	10·1
48 hours 480 deg. C. quenched and aged	15·8	12·0
48 hours 480 deg. C. tempered 48 hours at 250 deg. C.	13·8	9·4†
(2) Nitrate bath :—		
6 hours 480 deg. C. quenched and aged	14·6	12·8
6 hours 480 deg. C. tempered 48 hours at 250 deg. C.	13·2	11·0
48 hours 480 deg. C. quenched and aged	16·0*	13·7
48 hours 480 deg. C. tempered 48 hours at 250 deg. C.	16·0	12·0
(3) Nitrate bath :—		
6 hours 530 deg. C. quenched in boiling water and aged	21·0‡	—

* Maximum elongation at 15 deg. C., 2·25 per cent. on 2 in.
† Maximum elongation at 250 deg. C., 3·75 per cent. on 2 in.
‡ Elongation at 15 deg. C., 6·5 per cent.

Still more striking and important results have been obtained by heat treatment applied to castings of the alloy "Y." In the first place, prolonged annealing at a temperature near 500 deg. C. was applied, and this was followed by quenching and ageing, either at room temperature or at higher temperatures up to 250 deg. C. Some of the results obtained after various treatments of castings of this alloy are shown in Table I (IV)*. Attention is drawn to the high value obtained after heat-treatment at 530 deg. C., followed by quenching in boiling water, and ageing.

SECTION III; WROUGHT ALLOYS.

This section deals with alloys capable of being wrought by such operations as forging, rolling, extrusion, cold working, &c., and describes not only the mechanical properties of the alloys when heat-treated, but also their behaviour while undergoing working and the methods adopted in order successfully to produce them on a manufacturing scale.

III (*a*) *The Ternary Alloys of Aluminium, Zinc and Copper.*—A study of the behaviour and properties of the ternary alloys of copper and zinc with aluminium naturally followed the results of the Tenth Report to the Alloys Research Committee. The results of this study led at once to a further examination of the alloys containing 3 per cent. of copper with 20 per cent. to 25 per cent of zinc, which were mentioned in the previous report. Preliminary experiments carried out at the works of the British Aluminium Company convinced the authors that successful rolling of these alloys could be achieved. As soon as the experimental rolling-mill was installed at the National Physical Laboratory, a systematic study of these alloys was commenced. In the case of the "3/25" alloy (alloy B) considerable initial difficulties were experienced, and, in view of the urgent need for the production of a satisfactory light alloy, attention was transferred to the distinctly softer alloy, containing 3 per cent. copper and 20 per cent. of zinc (alloy A), whose properties are little inferior to those of alloy B, and which has the advantage of a slightly lower density.

A complete study was made of the different factors which influence casting, forging and rolling, and the

* Read before the Institution of Mechanical Engineers, on Friday, October 21, 1921.

*The figure in brackets refers to the number given to this table in the full report, of which this is a summary.

treatment necessary for success at all stages was carefully determined. Particular attention is drawn to the necessity for obtaining a casting free from surface defects and shrinkage cavities, and the necessary methods are described. Suitable regulation of the forging temperature and the amount of forging, as well as adequate lubrication of the rolls, were also found to be essential. By the suitable regulation of these and other conditions, billets were successfully broken down and rolled into bars, 1¼ in. or 1½ in. diameter, after which no further difficulty was experienced in reducing the alloy to any desired size. Certain new difficulties arose in connection with the production of sheet, especially when cast slabs of large size were used, and it became necessary further to study the casting conditions before the initial difficulties were overcome. The fact that the condition of the surface was largely responsible for cracking, which occurred during breaking down, was shown by results obtained in forging and rolling slabs whose cast surface had been removed in a planing machine to a depth of approximately ¼ in. After forging, these machined slabs gave practically perfect rolled blanks. By the use of various mechanical aids, of which the most successful was a small V-shaped groove, cut from top to bottom at one side of the slab mould, down which the metal was poured, satisfactory surfaces were obtained. After removing the small V-shaped runner on the edge of the slab, it was found possible to obtain forged and rolled blanks practically free from defects. Another difficulty in the early stages was low ductility in the transverse direction, which was overcome by cross-rolling with excellent results.

TABLE II.—Summary Table. Tensile Tests. Alloy "3/20." Density 3·1.

Material.	Condition.	Elastic Limit.*	Limiting Proof Stress.*	Yield Stress.*	Ultimate Stress.*	Reduction of Area, per Cent.	Elongation per Cent. on 2 in.
Rod.							
1¼ in. diameter	(1) Hot-rolled	11·8–13·0	—	17·6	26·4	29·8	17
1 ,,	,,	—	—	18·5	27·4	—	18
¾ ,,	,,	—	—	18·3	27·0	38·0	21
½ ,,	,,	—	—	17·4	26·7	—	30†
1¼ ,,	(2) Annealed 200 deg. C.	—	—	15·1	24·8	—	21
½ ,,	,, 225 deg. to 250 deg. C.	9·1	—	—	26·1	21·4	19
Sheet.							
0·104–0·048 in. thick	(1) Hot-rolled	—	18–21	16·9	27·2	—	19
0·020 ,,	,,	—	—	—	25·2	—	13–17
0·050 ,,	,, aged 4 years	—	—	27·0	33·0	—	16
0·104 ,,	(2) Hot-rolled, annealed 200 deg. C.	—	—	12·3	22·2	—	24–28
0·119–0·048 ,,	(3) Cold-rolled	—	—	26·0	29·7	—	11
	(4) Cold-rolled, annealed 225 deg. to 250 deg. C.	—	—	13·0	24·0	—	20
Wire.	Produced from ¼-in. rod by cold drawing with intermediate low-temperature annealing.						
0·063 in. diameter	(1) *As received* from Messrs. Wiggins	—	—	—	27·8	—	8‡
0·020 ,,	—	—	—	—	31·0	—	5‡
0·0125 ,,	—	—	—	—	27·3	—	2‡
0·063 ,,	(2) Annealed 250 deg. C.	—	—	—	20·7	—	14‡
0·020 ,,	—	—	—	—	22·3	—	9·5‡
0·0125 ,,	—	—	—	—	20·7	—	—

* All in tons per square inch. † On 1 in. ‡ On 4 in.

III (b). Cold Working.—In connection with the production of very thin sheet, and of spinnings of alloy "A," it was necessary to study the conditions under which this material can be cold-worked. At first, considerable difficulties were encountered through loss of ductility of the material, which was not restored by the annealing process adopted. An investigation into the annealing properties of the alloy showed that too high a temperature was being used (450 deg. C.), and by the adoption of a much lower temperature (250 deg. C.) successful results were obtained. It should be noted, however, that although material which has been cold-rolled and annealed at 250 deg. C. possesses considerable ductility, it is somewhat weaker than the same material in the "as rolled" condition, a difference of 3 tons to 4 tons per square inch being found. By the use of the treatment outlined above not only were successful spinnings of this material obtained, but it was also found possible to produce very thin sheet (0·0035 in. thick), having a tensile strength of 23 tons per square inch. With a more suitable set of rolls it is probable that this thickness could be reduced still further.

In the same way, no difficulty was found in the production from rolled rod of wire of any desired diameter, by cold-drawing with intermediate low-temperature annealing; wire of 0·0125 in. diameter was successfully produced by Messrs. Wiggins, of Birmingham, from ¼-in. rod rolled at the National Physical Laboratory. In the "as drawn" condition this wire possesses a tensile strength of 27 tons and, after annealing at 250 deg. C., a strength of 20·7 tons per square inch. A summary of tensile tests on this alloy in various conditions is given in Table II (XXXIX).

The data there given represent mean values derived in many cases from a large number of tests, and the authors consider that these values can readily be obtained in ordinary manufacture. The data referring to elastic limit represent the "Limit of Proportionality," as measured by means of a delicate extensometer. Results of further tests are given in the Main Report, and include shear tests (on sheet), in which values of 22 tons to 23 tons per square inch have been found, fatigue tests, some results of which are given in Table V of this summary, notched bar impact tests and low temperature tensile tests, carried out at temperatures of – 80 deg. C. and – 185 deg. C., which showed that such intense cold had no embrittling action.

III (c). Development of Alloys "E" and "Y."—Numerous attempts have been made throughout the course of this research to improve the mechanical properties of the alloys by making use of the hardening effect produced by the addition of small quantities of magnesium. Since the aluminium-zinc-copper alloys, whose development has already been described, have such good tensile properties, it was hoped that the application of the hardening effect due to magnesium would bring about a considerable further advance. The addition of magnesium immediately introduced further difficulties, and especially increased the difficulty of forging. Attention was therefore turned at this stage to the possibility of bringing these alloys into workable condition by use of the extrusion process, and a number of alloys were more or less successfully broken down in this manner and rendered suitable for hot-rolling. Of the alloys examined in this way, one in particular, having the following nominal composition:—

	Per Cent.
Copper	2·5
Zinc	20·0
Magnesium	0·5
Manganese	0·5
Iron	0·2 not exceeding.
Silicon	0·2 not exceeding.

was successfully extruded and rolled. After heat-treatment, which consisted in quenching at 350 deg. C. followed by ageing at room temperature, it was found to possess a primitive elastic limit of about 20 tons, a yield stress of over 32 tons and an ultimate stress of about 37 tons per square inch, together with an elongation of 11 per cent. to 12 per cent. on 2 in. By quenching from 400 deg. C., tensile strengths as high as 40 tons per square inch have been obtained. The above results constitute a considerable advance on any light alloy previously produced, so far as tensile properties are concerned, and special attention was therefore devoted to the further development of alloys of this type. For various reasons, it was considered desirable, if possible, to develop methods of breaking down the alloy which did not involve the use of extrusion. Experience gained in the production of alloy "A" suggested that the difficulties met with in forging these harder alloys might result from defects in the castings, and special attention was therefore given to this operation. The earlier difficulties were found to be due mainly to the method of adding magnesium, which had been introduced in the form of a magnesium-aluminium alloy containing 20 per cent of the former metal. Slabs produced in this way, when examined under the microscope, were found to possess serious defects, such as inclusions of oxide and unsoundness; by adding magnesium in the form of pure metal just before casting, in the manner already indicated, sound slabs were produced which gave much better results on working.

In spite of this, and of many variations in the methods of forging, edge-cracking during breaking down has never been completely eliminated. Once the material has been reduced 50 per cent. in thickness, however, and has been trimmed to remove cracked and defective portions, little further trouble with cracking is experienced. Subsequent to the successful production of this alloy, known as alloy "E," at the National Physical Laboratory, its manufacture on an industrial scale was studied and developed at the Royal Airship Works at Cardington, at that time under Messrs. Short Brothers. There the treatment was modified by machining the surface of the slabs, annealing them before forging, and using a heavier hammer and more drastic forging treatment. By these means the amount of scrap was considerably reduced, and in addition, it was found that the more drastic forging treatment produced an improvement in the ductility of the product.

Alloys "F" and "G."—In order to obtain a somewhat softer alloy, two modifications of composition, suggested by the authors, were tried at Cardington. The first of these, known as alloy "F," consists in the addition of a small amount of silicon (to bring the total silicon in the alloy up to approximately 0·75 per cent.). This makes the alloy slightly softer, and reduces the average tensile strength to 35 tons, as compared with 39 tons per square inch of the alloy "E"; the elongation is increased to 18 per cent., as compared with 15 per cent. of alloy "E." A further modification, leading to the alloy known as "G," was made by reducing the percentage of the added elements, zinc, manganese and magnesium. The composition is as follows:—

	Per Cent.
Copper	2·5
Zinc	18·0
Magnesium	0·35
Manganese	0·35
Silicon	0·8
Aluminium	Remainder.

This change in composition reduces the tensile strength very little as compared with alloy "F," but a considerable increase in elongation is obtained.

A summary of the tensile properties of alloys "E," "F" and "G" is given in Table III (XLi). These alloys, when suitably treated, give a wide range of properties, tensile strengths up to 40·7 tons per square inch being available. This latter figure is given by a treatment consisting in quenching at 400 deg. C. followed by ageing, and, as will be seen later, produces an alloy which is liable to fail somewhat readily by "season cracking." Quenching from a lower and perfectly safe temperature, such as 350 deg. C., gives an alloy with an ultimate stress of approximately 38 tons per square inch with a corresponding greater elongation.

Alloy "Y."—Reference has already been made in the section on "casting alloys for use at high temperatures" to certain alloys containing copper, nickel and magnesium, which not only possess a considerable degree of strength at high temperatures, but have remarkable ductility in the range of temperature which is usually employed for the rolling of aluminium alloys. Alloys of the type "A," "E," "F," and "G" are subject to certain limitations, since they lose their strength very rapidly with increase of temperature, are particularly susceptible to certain types of corrosion and, after certain conditions of heat treatment, they are liable to failure by "season cracking."

It therefore became desirable to look in other directions for alloys which, while possessing a reasonable degree of strength, should be as free as possible from these limitations. For this reason alloys of the "Y" type, containing copper, nickel and magnesium, have been developed. A large number of exploratory alloys containing various proportions of copper, nickel and magnesium have been made and tested, and, as a result of this preliminary work, attention has been concentrated on the alloy already referred to as alloy "Y," which gives the best results at ordinary and at high temperatures. With regard to forging and rolling, no particular difficulties were encountered beyond a little edge-cracking during the production of sheet. It was, however, found desirable to use higher forging and rolling temperatures than those which are suitable for alloys containing zinc. Some difficulty was at first experienced in obtaining tensile strengths appreciably greater than 22 tons per sq. in. in rolled material quenched from 480 deg. C. and aged. At a later date, however, considerable improvement resulted from the use of a higher quenching temperature, namely, 520 deg. C., and the use of boiling water as a quenching medium. Tensile strengths of 24 tons per sq. in., together with an elongation of 20 per cent., have been obtained. In the case of thin sheet, tensile strengths up to 28 tons per sq. in., together with an elongation of 17 per cent., have been obtained by cold-rolling, followed by quenching at 530 deg. C. and ageing. The tensile properties of alloy "Y" are summarised in Table IV (XLi).

General Comparison of Alloys "A," "E," "F," "G," and "Y."—Although the tensile properties of these alloys are given in Tables II., III. and IV. in a manner which renders comparison simple, there are many other properties which are of great importance in connection with their practical application. In particular, the fatigue range, both at ordinary and slightly elevated temperatures, is of importance in view of the possible use of these alloys for the working parts of machinery, such as connecting rods of aeroplane or automobile engines. The safe range of alternating stress which the material might, as the result of the Wöhler test, be expected to endure indefinitely is shown in Table V (XLV), which also includes tests on certain modifications of these alloys. Alloy "Y1" corresponds in composition with the normal alloy "Y," but with the addition of ½ per cent. of manganese. Alloy "Y2" contains both ½ per cent. of manganese and 0·75 per cent. of silicon. Alloys "D1," "D2" and "D3" are of the "Duralumin" type and contain 3 per cent., 5 per cent. and 6 per cent. of copper respectively. Alloy "M" contains 2 per cent. of copper, 1·5 per cent. of nickel and 1 per cent. of magnesium, with the usual impurities, and corresponds very closely to the alloy known as "Magnalite." Alloy "R" contains 6·1 per cent. of magnesium and the normal impurities. A general comparison of the data given shows that, particularly at somewhat elevated temperatures, the alloy "Y" is superior to any of the others. A remarkable and somewhat disappointing result is given by the alloy "E," whose fatigue range is considerably lower than might be expected from its tensile properties. Alloy "Y," although slightly weaker than the others, at ordinary temperature, is of special value because it is distinctly superior, both as regards tensile strength and resistance to all alternating stresses, at elevated temperatures, while it also combines with these properties immunity from "season cracking" and a very remarkable resistance to corrosion. It is certainly not more difficult to produce under manufacturing conditions than alloy "A," and in this respect it

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TABLE III.—SUMMARY TABLE. TENSILE TESTS. ALLOYS "E," "F" AND "G." DENSITY 3·1.

Material.	Condition.	Elastic Limit.*	Limiting Proof Stress.*	Yield Stress.*	Ultimate Stress.*	Reduction of Area, per Cent.	Elongation per Cent. on 2 In.
Rod.							
"E" ¾ in. diameter	(1) Hot-rolled	—	—	23·7	29·7	—	15
"E" ¾ in. diameter	(2) Quenched 350 deg. C.; aged 1½ hours	—	—	16·8	29·7	—	20
"E" ¾ in. diameter	Quenched 350 deg. C.; aged 5 days	22·1	—	32·9	37·8	13·4	12
"E" ¾ in. diameter	Quenched 400 deg. C.; aged 5 days	—	—	21·6	40·7	—	9
"F" ¾ in. diameter	Quenched 400 deg. C.; aged	—	—	25·3	36·0	21·4	16
Sheet.							
"E" 0·04–0·05 in.	(1) Hot-rolled	—	—	24·5	32·4	—	18
"E" 0·04–0·05 in.	(2) Quenched 400 deg. C.; aged	—	28–31	29·3	38·2	—	15
"E" 0·04–0·05 in.	(3) Hot-rolled annealed 250 deg. C.	—	—	14·5	25·3	—	20
"F" 0·04–0·05 in.	Quenched 400 deg. C.; aged	—	25–28	30·4	35·4	—	19
"G" 0·04–0·05 in.	Quenched 400 deg. C.; aged	—	24–25	30·6	34·6	—	19

* All in tons per square inch.

TABLE IV.—SUMMARY TABLE. TENSILE TESTS. ALLOY "Y." DENSITY 2·80.

Material.	Condition.	Elastic Limit.*	Limiting Proof Stress.*	Yield Stress.*	Ultimate Stress.*	Reduction of Area, per Cent.	Elongation per Cent. on 2 In.
Rod.							
¾ in. diameter	Hot-rolled			12·0	17·6	30·0	20·0
	Quenched 530 deg. C. and aged	7·7		15·4	24·1	33·0	23·0
¾ in. diameter	Cold-rolled from 1½ in. diameter hot-rolled, quenched 530 deg. C. and aged	7·7		15·2	24·2	34·0	25·0
½ in. diameter	Cold-rolled from ¾ in. diameter hot-rolled, quenched 520 deg. C. and aged			14·8	22·9	31·0	26·0
Sheet.							
	Hot-rolled, quenched 480 deg. C.; aged		12·6–14·9	16·2	23·2		19·0
0·05 in.	Hot-rolled, quenched 530 deg. C.; aged			17·2	26·0		19·0
	Cold-rolled, quenched 530 deg. C.; aged	9·8	17·5	20·8	28·9		17·0
0·018 in.	Cold-rolled, quenched 530 deg. C.; aged		19·0	21·0	28·0		17·0

* All in tons per square inch.

TABLE V.—*Fatigue Tests (Wöhler Method) on Wrought Alloys.*

Material.	Safe Range of Alternating Stresses.	
	20 deg. C.	150 deg. C.
Hot-rolled rod, ¾ in. diameter	± 8·7	± 4·5
Alloy A (3/20)	± 10·5	—
Alloy B (3/25)	± 9·7	± 5·1
Alloy E*	± 10·2	± 8·4
Alloy Y	± 10·3	± 8·2
Alloy Y_1*	± 9·0	± 6·5
Alloy Y_2*	± 10·5	± 7·2
Alloy D_1*	± 10·5	± 7·9
Alloy D_2*	± 10·2	± 5·0
Alloy D_3*	± 9·0	± 7·0
Alloy M	± 8·5	± 5·5
Alloy R		

* Heat-treated and aged.

is distinctly superior to the alloys "E," "F" and "G." Its specific tenacity is approximately equal to those of alloy "A" and "Duralumin."

III (d). Extrusion.—In order to overcome certain difficulties in breaking down many of the high-tensile alloys described in the report, experiments on extrusion were undertaken in co-operation with the British Aluminium Company and the Muntz Metal Company. Earlier experiments showed that many alloys could be treated by this process, and that such material could readily be rolled to smaller sections. Much of the extruded material contained longitudinal defects, which caused laminated fracture when bars are notched and broken by a blow. Experiments carried out with soft plastic substances, made of different coloured layers and extruded from small model cylinders, gave interesting results, which led to useful modifications in the extrusion process. It was found that the longitudinal central defect, which causes lamination, is due to the drawing down into the bar of ingot defects, particularly the central pipe, or of portions of the skin, particularly from the back of the original ingot. The authors, therefore, used ingots which were cast in such a manner as to avoid the formation of any considerable contraction cavity. The evil effect of such a cavity can be still further reduced by placing the top end of the ingot towards the die in the extrusion press. Drawing down of the rear surface of the ingot was prevented by placing between the ram and the billet a steel friction plate provided with corrugations.

With regard to mechanical tests, the tensile properties of extruded material of satisfactory quality are usually similar to those of the same alloy manufactured by forging and rolling. In a few cases, however, somewhat inferior results have been obtained.

(To be continued.)

A LOCOMOTIVE CHART.—The Locomotive Publishing Company, Limited, of 3, Amen Corner, E.C. 4, has recently published a chart of a standard six-coupled locomotive of the Midland Railway, of which Sir Henry Fowler, K.B.E., is chief mechanical engineer. The chart is No. 11, and costs 2s. net. The views given are sectional longitudinal elevation, two half end views, and two half cross-sections. The engraving is apparently reproduced from a tinted drawing, and in the reproduction the unevenness of the colouring has resulted unfortunately in a rather blotchy effect. This, however, does not detract from the utility of the chart, the parts being well distinguished and all numbered for reference to an index list of 175 items given below.

THE CITY OF CARDIFF.—A copy of an attractive booklet issued by the Development Committee of the Cardiff City Council, calling attention to the commercial advantages of the city and its suitability for the establishment of works and factories, has recently come to hand. Cardiff, it is pointed out, is served by four local railways and four main lines, as well as by canals giving communication with the South Wales valleys and the Midland counties. Facilities for overseas trade are, of course, exceptionally complete, and the supplies of coal, gas, water and electric energy are capable of meeting all requirements.

LIGNITE BRIQUETTING IN CANADA.—The coal situation in Western Canada is somewhat peculiar. Manitoba has no coal whatever; Saskatchewan has lignite, and Alberta plenty of coal. But the coal trade is little developed, and American anthracite is still the main domestic fuel of Western Canada. When the Canadian Government appointed a Lignite Utilisation Board in 1917, it was found that lignite briquetting had, in the United States, never gone beyond the experimental stage, and that German lignite differed too much from the Canadian product to adopt German methods. In the experiments which were started in Ottawa early in 1919, by the Board, of which Dr. R. A. Ross is chairman and Leslie R. Thomson is secretary (Journal of the Society of Chemical Industry, October 15, it was resolved to make pillow-shaped or oval briquettes, resembling the anthracite nodules to which the people are accustomed and to use a roll press, carbonising the lignite first at about 600 deg. C., for obtaining a fuel of high calorific value. Various binding materials were tried; the petroleum pitches and sulphite liquor pitches were dropped—temporarily at least—as too expensive, and most work was done with a combination of pitch with waste-flour screenings. The mixing was mostly done by edge runners, partly also by paddle mixers. The rolls of the small press are 2 ft. in diameter and operate at 10 r.p.m. or 11 r.p.m. The large plant, now in course of erection at Bienfait, Saskatchewan, has a daily capacity of 100 tons of briquettes. The 15-ton Belgian roll press has rolls of 26½ in. diameter and 11½ in. face, and contains 6 rolls of ovoid moulds, 36 moulds to the circumference; the briquettes weigh about 2 ounces each. So far the experiments tend to show that a first-quality commercial fuel can be briquetted from carbonised lignite with the aid of various binders, coal-tar pitch, petroleum pitch, hardwood tar pitch, or sulphite-liquor pitch, but much more of the binder is wanted than in anthracite briquetting. When sulphite pitch is used as single binder the briquettes require a subsequent heat treatment. If ordinary coal-tar pitch is used, 13 parts by weight are required per 100 parts of carbonised lignite. The price of the briquettes is to be 12·25 dols. per ton at the plant and 17·50 dols. at Winnipeg, where 20 dols. are paid for American anthracite; the briquettes are said to burn better than the anthracite, but have only ten-elevenths of its calorific value.

LOW-PRESSURE TURBINE BLADING FAILURES IN DESTROYERS.

By Lieutenant-Commander D. F. DUGEY, U.S.N., Member.

ON what might be termed the war programme, the following destroyers, equipped with impulse-type turbines, were built:—

Nos. 79–86, 95–102, 103–112, 161–170, 171–180, 251–260 and 261–295.

With the exception of a few minor items, the machinery installations of these vessels are identical, the approved plans for group 79–86, with developments and a certain few changes, having been used for all the succeeding groups.

The main propelling units of each destroyer consist of eight impulse-type turbines, these turbines, through reduction gearing, driving the two main shafts with their attached propellers. The turbine installation itself consists of one high-pressure, one intermediate-pressure and one low-pressure turbine, in each engine-room compartment. The high-pressure and intermediate-pressure turbines are in tandem, being connected by a slip coupling; the intermediate being connected to the so-called high-pressure pinion by another slip coupling. The low-pressure turbine, located inboard of the high and intermediate, through a slip coupling connection, drives the low-pressure pinion. Fig. 1, page 616, shows the general arrangement.

When operating at full power, about 27,000 h.p., live steam is admitted to the high-pressure turbine steam chest, and after expanding in the first stage, one-sixth of the flow passes through the high-pressure turbine, the remaining five-sixths passing to the steam chest of the intermediate-pressure turbine. Steam from the high and intermediate pressure turbines expands into the low-pressure turbine and is then discharged to the condenser.

The astern turbines, one for each shaft, are fitted in the same casings, and on the same shaft, as the low-pressure ahead turbines, and are capable of driving the vessel astern at a speed of 20 knots.

The main units are located symmetrically in each engine-room; the high and intermediate-turbines being outboard in each engine-room and the low-pressure turbines very close to the centre line. The port main shafting, forward engine-room, is 95 ft. 4½ in., and the starboard main shafting is 67 ft. 3½ in. in length.

From the above it can be seen that there is nothing unusual in the arrangement of the units, and that, with the exception of the greater length of the port line shafting, the port and starboard low-pressure turbines can be considered as operating under like conditions.

The low-pressure turbines are of the impulse type, having five rows of moving blades. Between rows are diaphragms, in halves, carrying the nozzles. The first and second rows are of monel metal and the third, fourth and fifth rows are of steel; these blades for groups 79–86, 95–102 and 103–112 being specified of chrome-vanadium steel, and for groups 161–170, 171–180 and 251–295 of chrome-nickel steel. The blades are of the usual impulse type section and of the following lengths:—

	In.
First stage	7·281
Second stage	9·281
Third stage	11·281
Fourth stage	12·281
Fifth stage	13·781

The active portion of the blade is approximately 1¼ in. less than the overall length.

The low-pressure rotor shaft, of forged steel, is 6 ft. 3 in. between centres of journals. The fifth stage wheel is 66⅞ in. in diameter over tips of blades; pitch circle, 54 in. in diameter.

At full power the propellers make about 450 r.p.m.; the corresponding speed of the low-pressure turbine is about 3,000 r.p.m. The test speed is 25 per cent. in excess of this and rotor wheels were spun accordingly. All tests were satisfactory.

The first destroyer of the 79–86 group was delivered on April 6, 1918, the remaining destroyers of this and the next group, 95–102, following at short intervals during the spring and summer of 1918. In so far as the main propelling units themselves were concerned, these vessels not only successfully completed their trials but have, in addition, cruised thousands of miles, under the varying and the exacting conditions required during war service, without a single blade failure of the kind under discussion.

While stripping turbine blading is not an unheard of occurrence, it certainly is not a common accident, especially where impulse blading is concerned; and, as a rule, when such an accident does happen, it is usually possible to arrive quickly at a definite conclusion as to the reason therefor. Therefore, in the late summer of 1919 when certain failures of low-pressure turbine blading occurred, and there existed much uncertainty as to the causes of these failures, a systematic investigation was undertaken.

The first vessel investigated was the No. 104, which was delivered to the Government on November 11, 1918. Some time after commissioning, while cruising at 25 knots, a blade, or several blades, in the second stage of the starboard low-pressure turbine, carried away. Whether or not the resulting condition was caused by just one blade letting go and tearing the others loose, or several blades going at the same time, could not be ascertained. Shortly after this accident, on August 26, 1919, while running a full power trial off Newport, R.I., six blades in the second stage of the port low-pressure turbine

* Reprinted from the Journal of the American Society of Naval Engineers, and slightly abstracted.

carried away. The turbine was opened and a careful examination made, but, as everyone knows, examining a stripped turbine is an undertaking of some magnitude, the general appearance being similar to a cubist picture with a couple of puzzle pictures painted over it. However, a careful search for foreign objects did not yield anything and, as far as could be ascertained, the clearances had been properly adjusted and the operation had not been abnormal. The workmanship was examined and, while it could have been improved upon, there was nothing apparent that one could say caused the accident. These assumptions being eliminated certain of the blades were cut up and the metal examined. The examiner's report was to the effect that the metal, in its then state, was unsuitable for turbine blading, a conclusion that seemed to be borne out by other information that came to light about this time, it being rumoured that certain of the blades for the 251–295 group, subsequent to the forging process, had been reformed and that during this process the metal was weakened. As a matter of fact it turned out later that no definite information could be obtained on this particular point. However, while there was no reason to doubt the existence of defective metal in the 104's blades, there were other facts involved that made it advisable to continue the investigation.

As far as could be ascertained all blades for the 104's low-pressure turbines were from the same stock and were manufactured at the same place and under like conditions; if some few blades failed from weakness of material, it could be expected that all should fail, as like conditions existed. However, the other blades did not fail. Moreover, it was a matter of record that 32 exactly similar turbines, like material and like manufacture, had functioned over a long period without a single blade failure. Also, following the 104, similar failures, that is, individual blades carrying away, occurred as per the lists below and in the next column:—

Destroyer Number.	Location of Blade Failures.	
	Turbine.	Stage.
104	S.L.P.	2
104	P.L.P.	2
173	P.L.P.	2
175	P.L.P.	3
176	P.L.P.	1
176	P.L.P.	2
178	P.L.P.	3
256	P.L.P.	2
272	P.L.P.	5
274	S.L.P.	4
280	P.L.P.	2
281	S.L.P.	3
281	P.L.P.	3
283	P.L.P.	2
284	P.L.P.	1
284	P.L.P.	4
285	P.L.P.	3
285	P.L.P.	2
285	P.L.P.	5
286	S.L.P.	3
286	P.L.P.	3
289	S.L.P.	2

As these failures occurred, in each instance, all the possible available data was obtained. This data was carefully compiled, but it was not until the early fall of 1920 that an actual clue appeared.

The port low-pressure turbine of the 280 was being re-bladed by the Vestal. In conjunction with the work the commanding officer made the following report:

"There is forwarded under separate cover one of the turbine blades of the third stage of the main low-pressure turbine of the 280, which is now on board the Vestal for re-blading of the second, third and fourth stages.

"The above blade is forwarded for the information of the bureau. The re-blading of this turbine shows that the new blades of the different stages are not all alike, but vary in the following particulars:—

(*a*) Length of blade.
(*b*) Thickness of root.
(*c*) Irregular position of tip.
(*d*) Shape of blade.

"In regard to (*a*), a few of the blades have been found to be shorter than standard. Regarding (*b*) some of the blades show different thickness of the root, and as a result it has been impossible to install the number of blades called for by the blue print. For instance, on the second stage which is now completed, the blue print calls for 288 blades, while it has been possible to use only 282 blades. Regarding (*c*) there are many blades where the tip is not central, being well over to one side or the other, this making it difficult to put shrouding in place. Regarding (*d*) there are quite a number of blades which are bent forward or back, or to one side or the other. The blade being forwarded has quite a bend to one side.

Blade Failures Designated by Groups.

Group.	Failures.	Location and Number of Blade Failures.	
		Turbine.	Number-Stage.
79– 86	0	—	—
95–102	0	—	—
103–112	2	S.L.P.	1-2
		P.L.P.	1-2
161–170	0	—	—
171–180	5	P.L.P.	2-2
			2-3
			1-1
251–260	1	P.L.P.	1-2
281–295	14	4 S.L.P.	1-2
		—	2-3
		—	1-4
		10 P.L.P.	1-1
			3-2
			3-3
			1-4
			2-5

Designating by Turbines.

Turbine.	Failures.
S.L.P.	5
P.L.P.	17

Designating by Stages.

Stage	First.	Second.	Third.	Fourth.	Fifth.
Failures	2	9	7	2	2

"These same difficulties were experienced in the monel metal blades of the second stage, which have already been put in place. These blades, however, were quite pliable and could be moved slightly so as to line them up and put the shrouding on. The steel blades of the third stage, of which sample forwarded was one, are not so pliable, and in an effort to move this blade so that the tip would fit into the slot of the shrouding, it snapped off. But very little force was used to move it and it seems to be very brittle. The dents and burrs on the root were made in getting it off the turbine after it was broken.

"Another irregularity noticed is in the shrouding. Many of the holes are not uniformly spaced, and the line of holes is seldom parallel to the edges of the shrouding.

"It is believed that this may throw some light on the trouble which a number of the destroyers are having. The blades and shrouding were received from the Mare Island Navy Yard."

About five months previous to the failure of the turbine blading on the 280, the port propeller was damaged and from that time on considerable vibration existed in the port shafting and turbine. The port propeller was removed and repaired, and the vibration eliminated to some extent. However, as the dock trial showed, there was still some vibration remaining, the 280, just previous to the time the blades failed, put out to sea and operated at various speeds to test out the shafting in deep water under service conditions. During this trial spin everything ran all right, and the 280 returned to port. A few days later, while warming up to get under way, trouble was experienced with the port low-pressure turbine, and investigation showed 15 blades carried away in the first stage. Apparently the blading had failed while warming up alongside the dock, but of this there was no proof. The blading may have failed during the run at sea several days before, as there are instances on record, in the case of the turbines in question, where stripping has occurred and not been discovered until the casings were lifted for other reasons; there being no indication at the time of the accident of anything out of the ordinary happening. This statement may appear a little out of the ordinary, in fact, the writer himself doubted it at first, but a rigid investigation showed it to be true.

On October 26, 1920, the commanding officer of the Vestal further reported:—

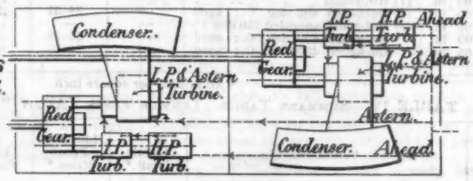
"There are forwarded under separate cover, blades from the third, fourth and fifth stages of the 280's main low-pressure turbine, in accordance with reference (*a*). There are no undamaged blades available as, in order to expedite removal of the old blades from the rotor, the blades were first cut off by means of an oxy-acetylene cutting torch. The roots were then driven off by a pneumatic hammer. The best blades and some of the blade roots have been selected.

"In addition, there is also forwarded a new blade which broke while installing on the fourth stage. The cause of this break is evidently brittleness. This blade was received from the Mare Island Navy Yard.

"There is also forwarded one new blade and piece of shrouding in the exact condition in which it was received

Fig. 1.

CURTIS TURBINES
No 79 to No 86 incl.
" 95 " 102 "
" 103 " 112 "
" 161 " 180 "
" 251 " 295 "
(7042.A)



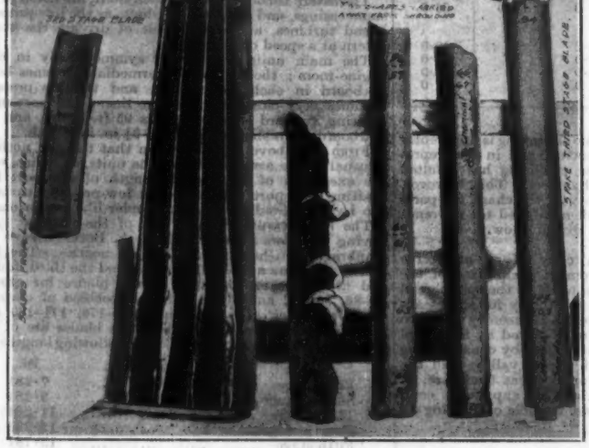


Fig. 2.

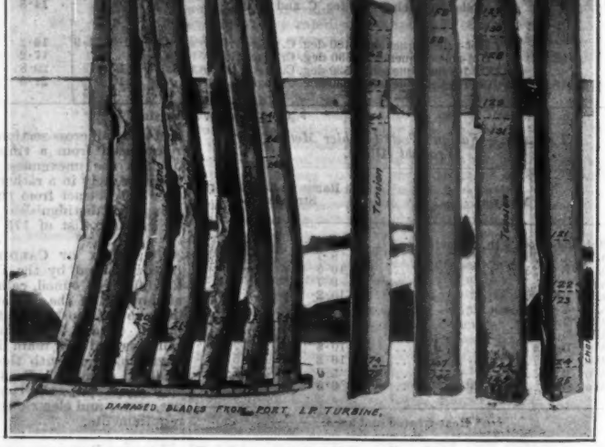


Fig. 3.

LOW-PRESSURE TURBINE BLADING FAILURES IN DESTROYERS.

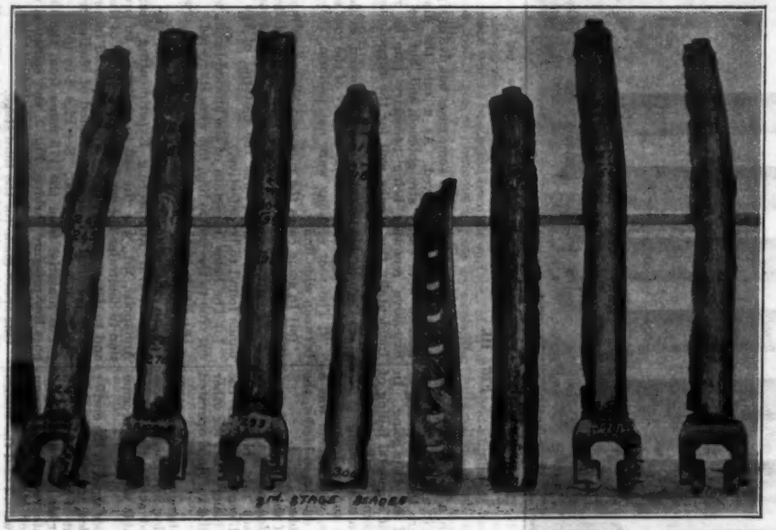


FIG. 4.

FIG. 5.

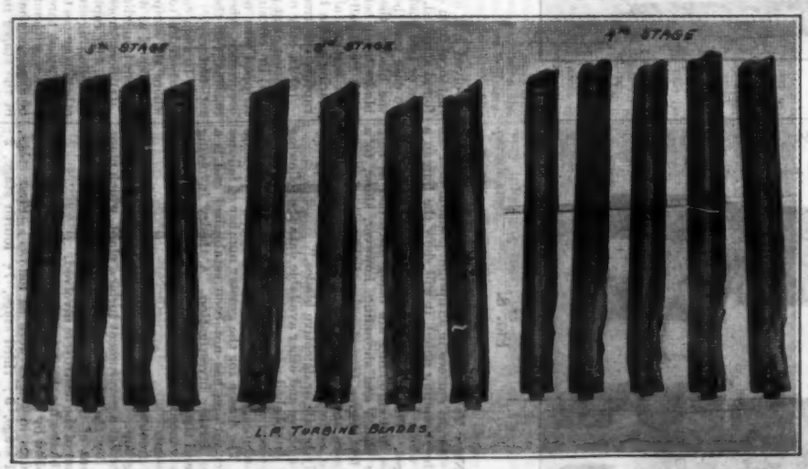


FIG. 6.

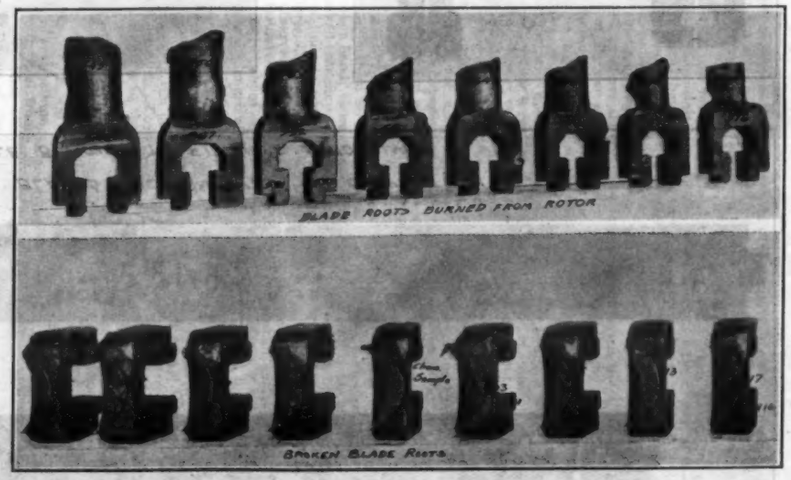


FIG. 7.

LOW-PRESSURE TURBINE BLADING FAILURES IN DESTROYERS.

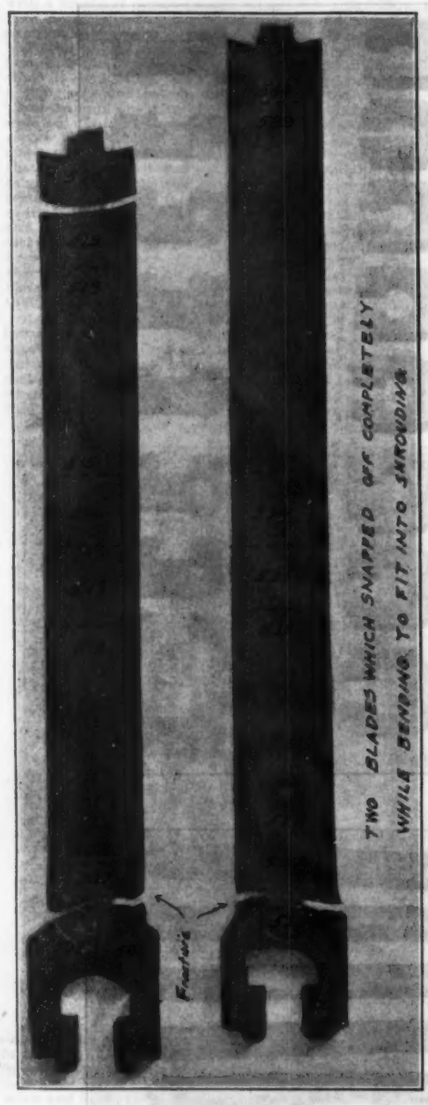


Fig. 8.

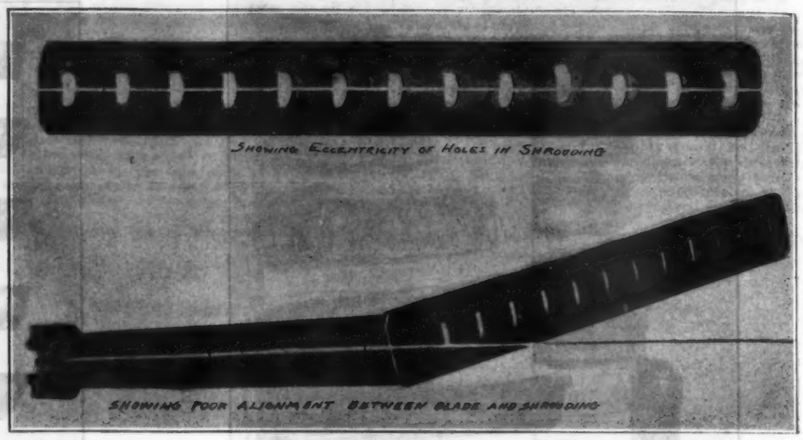


Fig. 9.

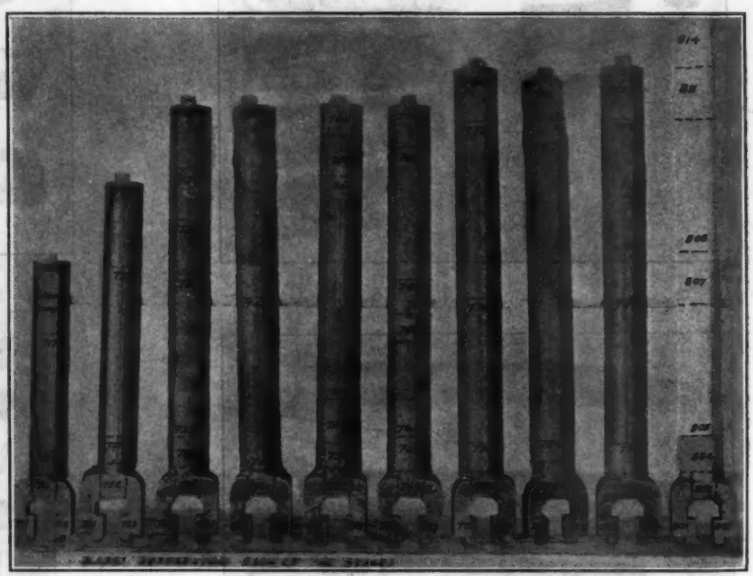


Fig. 10.

from the Navy Yard. If the root of this blade is placed against a straight surface in an upright position and the angle of the shrouding noted, it will show the bureau a condition which has been contended with in re-blading these stages. This is, however, an extreme case, and such blades and shrouding are being discarded as bad. All of the blades and shrouding, however, show, to a greater or less degree, irregularities of this nature.

"All blades are being tested before they are secured in place so as to reduce the chances of installing any particularly brittle or defective blades."

From the above and other available data the following facts were established :—

(*a*) Seventeen of the failures occurred in the port low-pressure turbines, and five in the starboard low-pressure turbines. The reason for the greater number of failures in the port turbine has not been established and is a subject for further investigation. A theory involving vibration and the greater length of the port line shafting has been advanced, but this can remain an open problem for the present.

(*b*) The greatest number of failures occurred in the 261–295 group. The blading of these turbines was accomplished at a government turbine plant, which plant was built by the Government and placed under the management of the firm holding the contracts for the construction of the destroyers involved.

(*c*) The blades for the 261–295 group were forged from stock supplied by one of the large steel corporations.

(*d*) Failures in stages were as follows :—First stage, 2; second stage, 9; third stage, 7; fourth stage, 2; fifth stage, 2.

(*e*) The primary failure as far as could be ascertained, involved but one or two blades in a single stage. In instances from one to fifteen blades in a single stage were found stripped, but indications were that the failing of one or two blades was the cause of the other going. In no case was there any indication of a general failing of the blades, the damage usually being confined to the blades being held by a single section of shrouding.

(*f*) Practically all of the blades ruptured across the root section, although in instances, where there was a tearing action by the shroud band and loose blades, the rupture occurred higher up on the blade.

(*g*) In only one instance, that of the 280, did serious vibration exist previous to the blades failing.

(*h*) In certain instances, the fact that blades had stripped was not discovered until sometime after the occurrence, when the casings were being lifted for other reasons. In the ensuing interval the turbines operated satisfactorily.

(*i*) In such cases, see (*h*), while there was no excessive vibration due to the loss of the blades, in those instances where the stripping was discovered at the time of its occurrence, as a rule a very noticeable vibration became evident immediately.

(*j*) Sometimes, when the failure occurred in the earlier stages, the ruptured blade or blades, in going through the following stages, tore blades out of these stages; in other instances the ruptured blade or blades went through as many as three stages and the intervening diaphragm nozzles, without tearing loose other blades. It would be expected that in such cases one would find the blades in the stages intervening between the stripped section and exhaust space, badly chewed up, but such was not always the case. The "chewing-up" was usually of minor importance and in some cases but five or six blades per stage were involved. As a rule the diaphragm nozzles were easily straightened, and but one case of extensive renewals being necessary can be recalled. Incidentally this speaks well for the ruggedness of the turbine design.

(*k*) Certain blades that failed showed evidence of cracks having existed in the vicinity of the root sections.

(*l*) The root sections were not uniform, they varied between wide-limits.

(*m*) In some cases the ruptured blade tore loose from the shroud band; in other instances the blades, even after rupture, failed to tear loose from the shroud band.

(*n*) In no instance was the material of the shroud bands found to be defective.

(*o*) The holes in certain of the shroud bands were not cut true to the centre line, but were staggered.

(*p*) Many of the blades, instead of being true, were slightly bent.

With the above information available, the United States Naval Engineering Experimenting Station at Annapolis, Md., was directed to undertake an investigation to determine the condition of the metal of the blades and to determine the cause of the repeated failures.

The material examined consisted of blading from the 178, the 175, and the 280. See Figs. 2 to 10.

The material from the 175 came from the damaged port low-pressure turbine, Fig. 2, and consisted of :—

One broken blade from the third stage.

One spare blade for the third stage.

Two blades which broke off from the shrouding, and the corresponding section of shrouding.

Damaged blades from the fourth stage.

The material from the 178, see Fig. 3, came from the damaged port low-pressure turbine and consisted of a section of damaged blading, including shrouding.

The material from the 280 came from the damaged port low pressure turbine and consisted of a number of broken and damaged blades from the third stage, Figs. 4 and 5, damaged blades and blade roots from the third, fourth and fifth stages (see Figs. 6 and 7), two blades which broke off while being installed in the third and fourth stages (Fig. 8), a new blade set in a section of shrouding, showing the lack of alignment between the two (see Fig. 9).

A series of unused blades representing each of the five stages and taken from the same lot as was installed in the low pressure turbines of the 175 and 178 were also examined. These are shown in Fig. 10.

(To be continued.)

THE SURFACE OF LIQUID STEEL.*

By COSMO JOHNS.

THE appearance of liquid steel as it flows from the launder of an acid open-hearth furnace was described in a communication by the author to the Faraday Society,† while the evidence for the existence of the vapour of iron or steel was reviewed in the course of a lecture‡ to the West of Scotland Iron and Steel Institute. Attention was specially drawn to the fact that an optically clean surface can be observed to persist for an appreciable length of time. An optical pyrometer using monochromatic light of a suitable wave length is a very convenient instrument for exploring such a liquid metal surface. The higher the temperature of the steel the longer does the liquid steel preserve its oxide-free surface. This can very conveniently be studied if a small quantity of liquid is poured into an open chill mould. If the temperature is sufficiently high and the pouring carefully done, the upper surface remains clear for several seconds, but, as the freezing point is approached, an oxide film begins to form and soon covers the surface. The same thing can be observed when liquid copper is poured into an open mould and is allowed to freeze. The preservation of the optically clean liquid metal surface was attributed by the author to the presence of the vapour of the metal, and the subsequent formation of the oxide film to the lowering of the vapour pressure as the freezing point of the liquid metal was approached. The presence of vapour of iron or steel above the bath of the open-hearth furnace seemed necessary to explain the gradual accumulation of oxide of iron, chiefly Fe_3O_4, in the pores of the silica bricks that line the hearth, and the well-known emission of reddish-brown iron oxide fume from the chimney during the stage in manufacture known as the boil.

When, however, this apparently rather obvious explanation was again advanced§ it failed to secure acceptance, and a very marked divergence of views was apparent among those taking part in the discussion which followed. Professor H. Louis doubted the possibility of iron vapour being formed and suggested the possibility of the formation of iron carbonyl. Dr. W. H. Hatfield could not agree as to the vaporisation of iron, and said that if a stream of metal were watched the conviction grew that the occluded gases were coming off and protecting the stream, and that if iron vapour were present there would be ocular evidence of its combustion and the formation of oxide. Professor Carl Benedicks thought that the main reason for the preservation of the surface was that the stream carried the air along with it, and that it was not running through air, but was protected by a covering of nitrogen. Only Mr. E. H. Saniter agreed with the author that the facts could best be explained on the assumption of the vaporisation of iron.

In the face of this divergence of opinion it was clear that further experimental evidence was desirable, and the object of this communication is to submit this further evidence. When a stream of steel, such as has been described above, is closely observed, a continuous shower of brilliant sparks can be seen to be ejected from the surface. Most of them end their flight as luminous objects by exploding with a brilliant flash. The length of the flight depends, of course, on their initial velocity and angle of emergence, but it is also related to the temperature of the steel and its chemical composition. The "sparks" can be collected in the exploded state and also examples found where disruption had not occurred. From their examination it could be seen that the miniature explosion which had ended the luminous career of so many, was caused by the accumulation of gas in the interior globule of steel during its oxidation in the course of its flight through the air, and that the hollow sphere of iron oxide had ruptured when the pressure became too great. Sometimes rupture occurred with the formation of two hemispheres and sometimes by the blowing out of a portion of the shell less in size than a hemisphere. The most probable explanation is that small globules of the steel are detached as a result of turbulence, and projected away from the surface as spray. These globules during flight would become oxidised and the gaseous products of the combustion of the carbon would accumulate in the interior, as oxidation progressed from outside to inside. It is just possible, however, that this explanation is not complete, and that their life history is not so simple.

Now, above the stream of steel, and easily to be distinguished from the sparks, a well-defined fume can be seen rising like smoke from the liquid metal surface and floating away to a considerable distance. It is evolved in greatest quantity near the tap-hole where it emerges into the air. There does not appear to be any graduation from "sparks" to fume; the sparks are distinct entities and can be separately distinguished from the fume. Samples of the fume were, therefore, collected—a few sparks would be included, but they would not be many in number. The sample could be collected on suitable collecting surfaces placed some distance away, but as the sample would only represent the portion that had been sorted out by gravity at that particular point it might not be representative. A simpler method was to use a magnet and collect the fume a few feet above the surface of the steel. An examination of the samples made it clear that the method of collection could be decided by convenience alone, for the fume was found to consist of small globules of iron oxide, most of them beautifully spherical. When the collection was made by allowing the falling particles to be caught on a receiving surface, the size of the globules did not vary very much, and the absence of extremely small spheres was noticeable. The fume collected with a magnet over the stream contained examples of all sizes, including a few "sparks," which could be distinguished. There was, however, one very striking difference in habit between the globules, constituting the fume, when collected with a magnet and those caught at a distance on a receiving surface. Those collected by gravity displayed no tendency to adhere or to attract each other. Owing to their spherical form it was difficult to retain them on a glass slide for examination. On the other hand, those collected with a magnet displayed a marked tendency to run together and form straight or curved lines, in which spheres of all sizes could be seen. Occasionally small groups of these little spheres could be observed, but the more common habit was to string themselves out in straight or curved lines, which could be moved about on the glass slide without coming apart unless the length of the string of spheres was excessive. This habit of adhering and forming strings or groups on the part of the globules that cooled in a magnetic field appears to be similar to that recently described by Professor Elihu Thompson* as characteristic of the "smoke" given off by the iron arc when used for electric welding. The agglomerating habit is, therefore, to be ascribed to the cooling of the iron oxide globules in a magnetic field which has rendered them magnetic.

The investigation was now directed to determining the origin of the fume. If it proved to be a form of spray, finer than the larger form which gave the sparks, then no light would be thrown on the nature of the medium, if any, protecting the surface of the liquid steel from oxidation. If, however, it could be shown that the minute globules represented the vapour phase of the metal after condensation and oxidation, an explanation would have been found. Samples of steel were, therefore, carefully collected from steel of varied but unknown composition. Now, an analysis of the fume, when recalculated to an oxygen free basis, would enable fume and original steel to be compared. If the fume was mere fine spray, then the oxygen-free fume and original steel would have analyses in substantial agreement. If the fume represented condensed and oxidised vapour, then differences should appear, for, on theoretical grounds, the various metals which are soluble in iron and can be investigated, in various concentrations, as alloy steels, would not be expected to vaporise at the same relative rate. Fume samples from several steels of very varying compositions were collected and analysed.† When recalculated to an oxygen-free basis they were all consistent in that the alloy metals differed as regards their percentage from those in the original steel, and made it clear that the fume in great part, if not almost entirely, represented the condensed and oxidised vapour of the steel. As the investigation will be continued, only one analysis will be given here, and that one contains the largest number of dissolved metals. The sample was carefully collected, and the oxide globules separated from the small quartz and fireclay particles and other impurities, which had been swept up from the sides of the launder by the strong convection currents found near the liquid steel. The ratio of the percentage of each metal in the original steel and their percentage in the fume, recalculated on an oxygen-free basis, was as follows:—

Element.	Original steel.	Fume.
Tungsten	1	0·58
Chromium	1	0·97
Iron	1	1·00
Nickel	1	1·23
Manganese	1	2·50

These values should be regarded as approximate only.‡ They serve to decide the point at issue, for they can only represent the vapour of a complex alloy steel whose constituents have evaporated at differential rates. They cannot possibly be construed as proving that the fume is the oxidised spray of the steel. As in many other recorded investigations, the solution of the immediate problem in hand only serves to suggest many new ones. Though it is proved that the fume does represent the condensed and oxidised vapour of the steel, it does not follow that the ratios tabulated give the absolute rate at which each of the metals evaporate at the temperature of liquid steel. There are difficulties in securing samples sufficient in weight for reliable analyses from steels of known composition. When collected with a magnet any non-magnetic material in the fume would escape collection. If the cooled fume be collected as it falls at some distance, then gravity separation would have been effected and the result is unknown. Collecting the fume by aspiration or some other method from near the surface of the steel involves difficulties which have not been overcome. Thus there are considerable difficulties in collecting the sample. Then the results which have been obtained suggest that the degree of concentration of the various metals have some effect on the rate of evaporation, and it is just possible that the presence of other elements in the solution is a factor not entirely negligible.

A search through relevant literature, admittedly not complete, failed to disclose any experimental work on the nature of the vapour of alloy steels. Our knowledge of the state of molecular association of the elements in such a complex liquid alloy as that studied, is practically nil. What is clear, however, is that a most interesting field of research has been opened out. The work is of great scientific interest, but it also has important industrial applications. The use of optical pyrometers for the determination of the temperature of liquid metals has only been successful where the method of observation has been standardised, and the pyrometer readings used directly for comparison without any attempt being made to apply corrections to obtain real temperatures. The presence of the vapour of the steel as a protecting atmosphere round the stream would mean that the absorption of the light emitted by the liquid metal would vary with the angle of observation. The condensed and oxidised vapour rising in a cloud would also mean considerable absorption of light. The phenomena is not confined to steel, for it should be still more marked with the non-ferrous alloys, especially those containing the more easily vaporised elements, and possibly explains the difficulty experienced in applying optical methods for the determination of their apparent or real temperatures.

* A paper read before Section B of the British Association, at Edinburgh, September 13, 1921.

† Cosmo Johns, "The Determination of the Temperature of Liquid Steel under Industrial Conditions." Transactions of the Faraday Society, Vol. XIII., 1918.

‡ Cosmo Johns, "The Solid and Liquid States of Steel," Journal of the West of Scotland Iron and Steel Institute. Lecture delivered December 20, 1918.

§ Journal, Iron and Steel Institute, No. 11, 1919, page 180 *et seq.*

* *Nature*, June 23 and July 14, 1921.

† I have been much indebted to Mr. J. H. Huxley, F.I.C., A.R.S.M., under whose supervision the several analyses were made, for the interest he has taken in the investigation.

‡ A less complete series of varying ratios was communicated at the time the paper was read.

CATALOGUES.

Oil Engines.—A small pamphlet giving notes about the supply of fuel oil and petrol comes from Messrs. Ruston and Hornsby, Limited, Lincoln.

Electricity Transformers.—We have received a list of three-phase oil-cooled transformers from Messrs. Guy Chantrill and Co., electrical engineers and exporters, 6, Norfolk-street, Strand, London, W.C. 2.

Small Oil Engines.—A catalogue of small engines made by the Cummins Engine Company, U.S.A., comes from Messrs. Melchior, Armstrong and Dessau, Limited, 14, Great Marlborough-street, London, W. 1. The sizes, in brake horse-power, are 1½, 3, 6, 8.

Condensers.—A copy of a new edition is to hand of the catalogue of condensers, pumps, cooling towers, feed water heaters and various kindred machinery, issued by the Wheeler Condenser and Engineering Company, Carteret, New Jersey, U.S.A. Marine and land condensers are included.

Engines.—A catalogue of petrol, oil and gas engines, ranging from 2 b.h.p. to 28 b.h.p., is to hand from R. A. Lister and Co., Limited, Dursley, Glos. These are fixed vertical engines suitable for dynamo driving or any similar work. This firm also supply a four-pole design dynamo with an output of 55 volts to 75 volts 14 amperes, at 1,900 r.p.m.

Heat Treatment.—A catalogue received from the Automatic and Electric Furnaces, Limited, 281, Gray's Inn-road, London, W.C. 1, contains very full and well-arranged particulars of furnaces, baths and instruments for heat treatment and also some excellent explanatory matter as to their proper use. The same firm send a very informing four-page leaflet on the hardening of carbon steel.

Building Materials.—Messrs. Fredk. Braby and Co., Limited, Petershill-road, Glasgow, send a catalogue of steel building materials including corrugated, ridged, flat and curved sheets, gutters, rain pipes, casements, fencing and practically all standard materials, as well as boilers, tanks, and other fittings and steel wheelbarrows and utensils for builders, farmers and others. We note that their works are still being extended to produce larger quantities and varieties of these materials.

Boiler Tube Extracting Tool.—A tool devised for extracting boiler tubes has been made with a plug which fits into the tube end and three jaws which close on the outer surface of the end. An easy and powerful screw and wedge gear is then operated by hand to force in the expanded ends. The tool is then loosened and turned to repeat the operation, until the end is reduced to normal size, when the tube can be driven out without damage to the plate. The catalogue describing this appliance comes from Mr. O. N. Beck, 11, Queen Victoria-street, London, E.C. 4.

Coal-Cutting Machines.—The various coal-cutting machines in use, chiefly known as disc, bar, chain, percussive and rotary-heading types, are cutting about 10 per cent. of the coal output of this country, and are also used, to some extent, in fireclay and ironstone mining. Compressed air is the chief motive power, though electric current is also used. These, and other facts are given in some catalogues received from Messrs. Cowlishaw, Walker and Co., Limited, 14, Cockspur-street, London, S.W. 1, with particulars of some fine examples of electrically-driven machines of the bar and chain types. It is claimed that the machine will increase output, reduce labour, and lessen wastage of coal, but skill and strength are still required in the miner.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

167,063. W. H. Boorne, London. Electrode. (2 *Figs.*) June 30, 1920.—An electrode for arc welding, metal cutting and analogous purposes comprises a metal core *a*, a complete coating of flux producing material over the core, a substantially non-

Fig. 1.

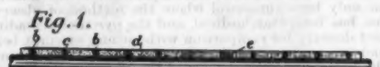
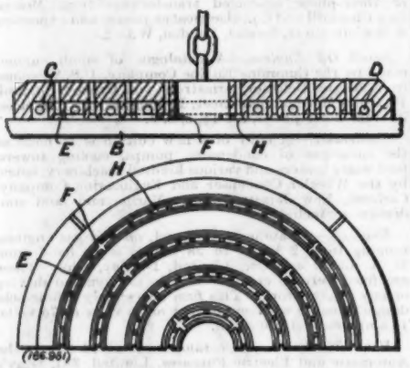


Fig. 2.

conducting material *b*, *c*, spirally wound over the coating, and flux-producing material, *d*, between the windings *b*, *c*. The material *b*, *c*, is wound in two directions with the spirals crossing each other. (*Accepted August* 10, 1921.)

166,931. J. Neale, Oxshott. Electromagnets. (5 *Figs.*) April 22, 1920.—An electromagnet designed for lifting steel plates of a given thickness is arranged with a series of annular and concentric coil recesses, C, and a corresponding series of annular and concentric pole faces, the coils D being wound so as to create opposite poles, and the pole faces being of such dimensions and cross-section that the plates B, which the magnet is designed to lift, will provide a cross-section equal to the corresponding cross-section of the magnetic circuit of the magnet.



As a further feature of the invention, the shell of the magnet is formed with a series of passages E at right angles to its active face permitting the circulation of water when the magnet is used under water for raising sunken objects. Radial gaps, F, and concentric grooves, H, establish communication between the passages E. If the magnet is used for land purposes, the passages E are connected up to a circulation system and air or liquid is forced through the recesses, C, and passages E. (*Accepted August* 10, 1921.)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

166,986. E. A. Ashby, Putney. Internal-Combustion Engines. (2 *Figs.*) April 27, 1920.—In an internal-combustion engine, according to this invention, the lubricating oil that falls to the bottom of the crank-case, A, is allowed to flow by gravity into a sump or container D, through a passage controlled by a tubular valve B, which is rotated by the engine so as automatically to open and close the passage between the crank-case and the sump at the desired period during the working of the engine.

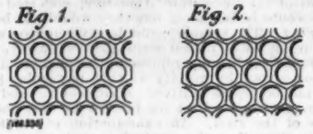
Fig. 1.

Fig. 2.

The oil in the sump is used again and is lifted from the sump by a pump. The valve B has ports *b*, and is closed at its ends and disposed in a bearing member, C, attached to the floor of the crank-case. The sump is attached to the lower part of the crank-case and the bearing member is formed with slots *c*, *c*1, in its upper and lower walls, the upper slot *c* registering with a slot *a* in the floor of the crank-case, and the lower slot *c* communicating with the interior of the sump. (*Accepted August* 10, 1921.)

166,930. C. A. Brown, London. Radiators. (5 *Figs.*) March 19, 1920.—The improvements relate to tubular heat exchangers for cooling, or for heating, or evaporating, fluids, of the kind composed of tubes having their ends bulged in flat-sided hexagonal form and fitted and connected together. According to the present invention, the bulged hexagonal end form is retained, but the cross-section of the bulged ends is modified so that the interstitial spacing between the tube bodies in the directions normal to the flow of the divided streams is less than,

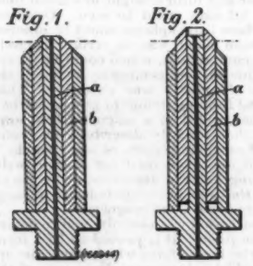
Fig. 1. Fig. 2.



or approximately one-half of, the spacing in the direction normal to the flow of the full or united half-streams. In carrying out the invention, according to one form, the tubes are of circular cross-section and have co-axial bulged ends of hexagonal form, in which all the angles are equal, but the pair of opposite sides which are arranged parallel to the direction of flow of the full streams are shorter than the other four sides, which are equal, as shown in Fig. 1. In a modification, the opposite angles are equal and the opposite parallel sides are equal, as shown in Fig. 2. (*Accepted August* 10, 1921.)

166,944. B. E. Alywin, Hampstead Heath, London. Carburettors. (3 *Figs.*) April 20, 1920.—According to this invention, the throttle is dispensed with, and the throttling effect is applied at the jet *a* of the carburettor. About the latter is fitted a sleeve *b* which, when the engine is being started up, is caused to assume the position shown in Fig. 1; the access of the air stream to the jet orifice is thus unimpeded and a rich combustible mixture results. For the running position, the sleeve *b*

Fig. 1. Fig. 2.

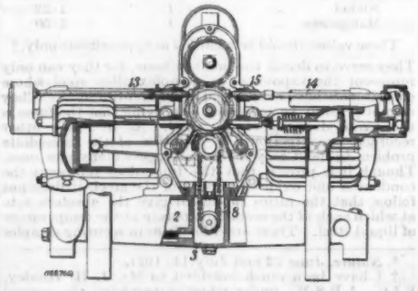


is moved axially, until, as shown in Fig. 2, its upper extremity is at such a height as to afford some slight obstruction to the path of the air stream; a less rich mixture, suited to normal running, results. The strength of the mixture diminishes as the sleeve *b* is further moved axially; whilst, to throttle fully the supply of combustible mixture, the movement is continued until the effect is to eliminate practically the influence of the air stream upon the jet. (*Accepted August* 10, 1921.)

166,985. G. Howell, Brighton. Sparking Plugs. (1 *Fig.*) April 27, 1920.—The central electrode of a sparking plug consists of a piece of cold-rolled steel 3 carrying a pure nickel point 4,

and the central tubular insulating member 5 is of asbestos paper. The two outer insulating members 6, are of mica impregnated with a varnish consisting of a phenol-formaldehyde compound. (*Accepted August* 10, 1921.)

166,766. J. Wooler, Alperton. Lubricating Internal-Combustion Engines. (1 *Fig.*) May 13, 1920.—In internal-combustion engines in which oil is picked up by an endless chain and delivered to the crank case, the engine has, according

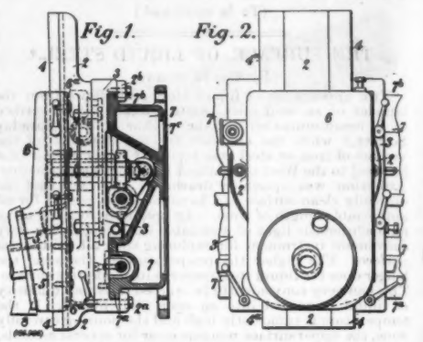


to this invention, a filtered oil well 3 in the sump 2 positioned outside the crank case, and the chain 8 lifts the oil and throws it to channels 11 communicating with the crank case. The well is open to a space or chamber 15 into which sliding hollow rods 13, 14 project for the purpose of conducting oil vapour (lubricant) to distant parts of the engine. (*Accepted August* 4, 1921.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

166,996. The Robson Machine Tool Company, Limited, Keighley, and G. S. Townsend, Keighley. Vertical Boring and Turning Mills. (3 *Figs.*) April 29, 1920.—In machine tools in which the tools and their carriers are supported by arms from a vertical pillar, and overhang a revolving table which carries the work, the construction and arrangement of the sliding parts carrying the tool-holder and the base upon which they are mounted, have heretofore been such that the work being carried out is so far removed from the surface affording support for the tools in action that considerable vibrations are set up which detrimentally interfere with the efficiency of the machine. In accordance with this invention, the base 3 of the radially-

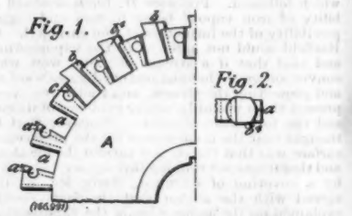
Fig. 1. Fig. 2.



adjustable support 2 is formed of a greater width than heretofore, and its guiding and supporting flanges 2*a* and 2*b* are arranged to clip over the guiding surfaces 7*a* and 7*b* of the bracket, instead of similar supporting or holding flanges being fixed upon the bracket 7. By this means the support is brought as near as possible to the base or vertical support of the machine, to which the fixing surface 7*c* of the bracket 7 is secured. Also the support 2 is formed with guiding edges 4, 4*a* in order that the flanges 6*a* of the base piece 6 may be to the rear of the edges 4, 4*a*. The support 5, upon which the rotary member or turret, 8, is mounted, is thus brought as near to the supporting surface 7*c* as is possible, on account of the disposition of the supporting flanges 6*a*, 6*b* and 2*a*, 2*b*. (*Accepted August* 10, 1921.)

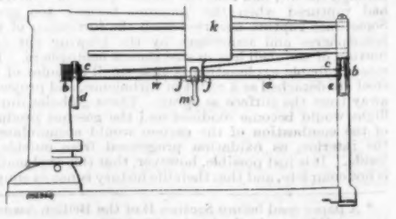
166,991. Sir H. Austin, Bromsgrove. Milling Tools. (6 *Figs.*) April 28, 1920.—The invention relates to milling tools of the type in which cutters are arranged radially about the periphery of a rotating disc, and in which each cutter has a cylindrical base adapted to fit into a correspondingly-shaped hole in the periphery of the disc. According to one feature of the invention, each cutter *b* is retained in its respective recess *a*, by a transverse pin *c*, which lies within a transverse hole *a*1, formed partly in the

Fig. 1. Fig. 2.



base of the cutter, either at the front or back thereof, and partly in the wall of the radial recess. The pin *c* may be cylindrical and the ends riveted over, or the pin may be in the form of a tapered cotter. According to another feature of the invention, the holes *a* are of a diameter greater than the thickness of the disc A, so that the holes run out at the sides of the disc; the cutters are flattened at their sides as shown at *b*1 (Fig. 2). (*Accepted August* 10, 1921.)

166,844. James Archdale and Co., Limited, Birmingham, and J. Jewsbury, Handsworth, Birmingham. Radial Arm Drilling Machines. (6 *Figs.*) October 18, 1920.—The stay which is used to connect the outer end of the radial arm to the base or table to increase the resistance of the arm to upward deflection when the drill is in operation, is locked to the base or table, and the radial arm is locked to the pillar which carries it, simultaneously by a single lever. The horizontal shaft *a* extends the full length of the radial arm *w*, and at each end



has helical wheels *b*, *b*, which engage complementary members *c*, on a pair of vertical shafts *d* and *e*, respectively connected to the arm and stay locking devices. The shaft *a* passes through lugs *f* on the saddle *k*, and on the shaft is feather-keyed an operating hand lever *m* mounted between the lugs, so that the lever moves along the shaft with the saddle. Angular movement of the shaft *a* by the hand lever *m*, causes the shafts *d* and *e* and the locking devices operated by them, to be actuated. (*Accepted August* 4, 1921.)